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The Effect of Electronic Feedback on Anesthesia Providers' Timely Preoperative Antibiotic Administration

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The Effect of Electronic Feedback on Anesthesia Providers' Timely Preoperative Antibiotic Administration

by

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Dedication

I would like to dedicate this project to the people that have worked tirelessly to make the completion of this research and manuscript possible. First props go to God, my wife and cheerleader Michelle, the members of my doctoral committee and other faculty who contributed and encouraged me to press on. I would also like to thank my friends for tolerating me while I endeavored to complete this pursuit. The research would not be possible without David Rosas, who is the smartest and most talented computer scientist/code slinger/database administrator I have ever met. I would also like to thank the clinicians and administration at the unnamed hospital somewhere in the United States who agree to participate in projects like this to make opportunities like this possible.

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ABSTRACT

The growing presence of electronic anesthesia record keeping and perioperative informatics systems is contributing to a database of valuable information that can significantly improve patient care and patient outcomes. Efforts such as the National Surgical Quality Improvement Project and the Surgical Care Improvement Project have analyzed quality measures that directly correlate to patient outcomes. Several of these quality indicators are influenced by the performance of anesthesia providers' activities in the perioperative period. These programs promote timely administration of preoperative antibiotics. One of their guidelines states that preoperative antibiotic should be given within an hour prior to surgical incision.

Surgical site infections are the most common postoperative complication. Reducing postoperative complications can reduce health care costs, and postoperative morbidity and mortality rates. The purpose of this project was to utilize an electronic feedback mechanism to improve anesthesia providers' documentation of timely preoperative antibiotic administration.

Electronic feedback reminders in the form of screensaver dashboards displaying updated departmental timely antibiotic percentage metrics for the day, the past week, and the past month were displayed for 16 weeks. Text messages were delivered once a week for 6 weeks showing an anesthesia providers' prior average one week on time antibiotic along with an equivalent department on time average. The measures were effective in improving the documentation of timely antibiotic administration.

CHAPTER ONE: INTRODUCTION

The goal of improving patient care in the hospital should be pursued constantly by those in the health care field. Interventions aimed at improving the type of treatments delivered, the patient's safety while staying in the hospital, and better selection and timing of pharmacologic therapies, have been implemented in many hospitals with this goal in mind. Over the past decade, a national surgical quality initiative called the National Surgical Quality Improvement Project (NSQIP) was tasked to measure and improve the quality of patient care on a national level. New discoveries were made concerning the correlation of data collected such as timely preoperative antibiotic delivery, normothermia maintenance, and euglycemia. When performance of these measures improved, postoperative morbidity and mortality decreased (Doenst et al., 2005; "History", 2006; Kurz, Sessler, & Lendhardt, 1996).

With the growing presence of electronic anesthesia information systems (AIS), it is now possible to harness the readily available data and provide feedback to providers and organizations. Today's AIS' harvest anesthetic data including: patient physiologic data, medication administration doses and timing, surgery duration, and staff utilization. These data can be easily compiled and reviewed for analysis. The final step in closing the loop is to make this process more rapid and provide feedback to the provider who generated the data in a meaningful way. The provision of meaningful feedback may have the potential to motivate improvement or continued excellent performance (Franklin, Rosenbaum, Carey, & Roizen, 2006).

The administration of the preoperative antibiotic is significantly influenced by the anesthesia provider. This project examined the effects of electronic feedback generated by an AIS on the performance of anesthesia providers' administration of a preoperative antibiotic within one hour of surgical incision.

Purpose

The purpose of this study was to examine the effectiveness of electronic feedback given to anesthesia providers' about their performance of timely preoperative antibiotic administration. Specifically, it sought to answer the question: will the use of electronic feedback containing data from an anesthesia information system affect anesthesia providers performance in documenting the timely administration of a preoperative antibiotic?

The hypothesis was that the overall proportion of patients receiving timely preoperative antibiotics would increase. It was hypothesized that by observing aggregate scores of their peers, individual providers would seek to improve their scores. Ideally in a weekly department meeting, the overall scores (anonymous) could be reviewed for the department as a whole to get feedback on departmental performance, further motivating participants who have scores below the norm to improve performance during the next week.

The increasing presence of electronic anesthesia record keeping systems and perioperative informatics systems generate large volumes of data. Often these data are recorded and not examined in a meaningful way by those who generate the data. By parsing data known to have significant effects on patient outcomes, and returning it to providers in a meaningful way via multiple modalities (electronic department billboard and screensaver applications, text messages, department meetings, etc), it was hypothesized the documentation of timely perioperative antibiotic administration would improve.

Definition of Terms

EARK: Electronic anesthesia record keeper. This is a software program that records data generated by physiologic monitors, anesthesia ventilators, and the anesthesia providers concerning the course and activity of an anesthetic. It includes timed entries of important events, physiologic parameters such as heart rates, blood pressures and respiratory rates, and all medications and fluids that are administered during the course of an anesthetic.

AIMS: *Anesthesia information management system.* This is a larger system of computers that includes the EARK as well as the servers and databases. It saves the data for the purpose of analysis.

HTML email: Hyper text markup language email. An email providing integrated graphics and text that are manipulated by the receiver's email client for proper rendering.

Microsoft .NET 3.5 services. The .NET Framework provides a managed execution environment, simplified development and deployment, and integration with a wide variety of programming languages. For a brief introduction to the architecture of the .NET Framework, see .NET Framework Conceptual Overview. For a discussion of .NET Framework version 3.5 and its relationship to previous versions of the .NET Framework, see .NET Framework 3.5 Architecture.

Preoperative antibiotic. A medication frequently given via intravenous route for the purpose of reducing the likelihood of infection.

Primary key. Uniquely identifies each record in a table. They can consist of a single attribute or multiple attributes in combination.

Relational database. A database that contains information which is interrelated and connected through the use of various database keys contained in the database's tables. They are easily extended and managed through Structured Query Language (SQL).

SCIP: Surgical Care Improvement Project. A national surgical quality improvement project with the goal of reducing morbidity and mortality in surgical patients by 25% by the year 2010. It began in 2005.

SIPP: Surgical Infection Prevention Project. A collaborative effort of the Centers for Medicare and Medicaid Services (CMS) and the U.S. Centers for Disease Control and Prevention (CDC). Three performance measures were developed: Administration of the prophylactic agent within 60 minutes prior to incision; selection of an agent from a roster of suitable agents chosen for narrow spectrum and safety; and discontinuation of prophylactic antibiotics by 24 hours after conclusion of the surgical procedure.

SMS: Short message service. Known also as a text message. Text data is sent from a source to a cellular device that is capable of displaying this digital content in text form.

Stored procedures. Precompiled database queries that improve the efficiency and usability of a database server application. They are stored in terms of input and output variables. These variables are then compiled into the code on the database and are made available for other applications or services.

SMTP: Simple Mail Transfer Protocol. It is designed for reliable and efficient mail transfer and is widely used in government and education facilities. It is also the standard used by the Internet for mail transfer.

SQL: Structured query language. It is a database computer language designed for managing data in relational database. It relies on relational algebra and its scope includes data query, update, schema creation and modification, and data access control.

Surgical incision time. The time recorded on the anesthetic record to mark the beginning of a surgical procedure. Typically this is when the surgical instrument touches the patient's skin.

Timestamp. An electronic marking in the EARK database that identifies when a particular item was inserted into the database.

Userstamp. An electronic marking in the EARK database that identifies a particular user that was logged into the computer system when a piece of data was inserted into the database.

Visualizer RSS screensaver. A screen saver on OS 10.5 for Macintosh computers that reads xml data from a Real Simple Syndication (RSS) feed and displays it in sequential order in a manner that visually draws the attention of a nearby viewer.

CHAPTER TWO: REVIEW OF LITERATURE

This chapter outlines the search strategies used for finding the literature and reviews that are relevant evidence foundational to this research. Evidence is reviewed that supports the administration of antibiotics to prevent surgical site infections, as well as the timing of the antibiotic administration that minimizes the likelihood of infection and other post operative complications. Guidelines for antibiotic administration are reviewed and discussed. This is followed by a review of the evidence supporting the effectiveness of electronic feedback to promote human behavioral change, including feasibility and practicality.

Search Strategies

The Cochrane Effective Practice and Organization of Care (EPOC) specialized register, Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE from 1980 to November 2003 and PubMed were searched using the terms “preoperative antibiotic”, “feedback”, “electronic”, “behavior change”, health care provider”. Additional studies were obtained from the bibliographies of retrieved articles. The reference document American College of Surgeons National Surgical Quality Improvement Project website was also utilized to locate foundational articles for the improvement of surgical outcomes.

Surgical Site Infections

A surgical site infection (SSI) is a form of postoperative complication that contributes significantly to morbidity and mortality in healthcare today and are the second most common type of nosocomial infection. The Centers for Disease Control (CDC) estimates that up to 500,000 SSIs occur annually in the United States (Bratzler, Houck, & Richards, 2005; Cheadle, 2006; Emoril & Gaynes, 1993; Khuri et al., 1995). The Department of Veterans Affairs has been monitoring surgical infection rates in their patient population for over 20 years and estimates nosocomial infections might account for up to 5.1% of all operations performed. Their extensive experience in this area suggests that the actual number of reported SSIs annually in the United States is under reported and maybe as high as 750,000 annually (Cheadle, 2006). Patients who experience a post operative complication are more likely to incur increased length of stay at the hospital, increased morbidity, and significantly increased costs (Bratzler & Hunt, 2006).

Patients who develop SSI are 60% more likely to spend time in the intensive care unit (ICU) and have twice the mortality incidence (Gleason et al., 1999; Kirkland, Briggs, Trivette, Wilkinson, & Sexton, 1999). The incidence of postoperative complications is as high as 30% in high risk surgeries and SSI are among the most common complication (Bratzler & Hunt, 2006). Among surgical patients, SSIs account for 40% of all hospital acquired infections (Miller & Roche, 2007). A postoperative complication contributes to dramatically increased length of stay (LOS), cost, and mortality. LOS could be 3-11 days longer than patients who do not have a complication (Bratzler & Hunt, 2006).

In 1980 the occurrence of an SSI increased a patient’s hospital stay by ten days and incurred a cost of an additional $2000.00 (Cruse, 1981). In the early 1990s the LOS related to SSIs decreased to 7.3 days, with the cost estimated to be $3,152 (Martone, Jarvis, Culver, & Haley, 1992). Recently, the estimated cost of a postoperative complication related to infections is estimated to be up to $1,398, cardiovascular complications cost $7,789, and respiratory complications cost $52,466 (Dimick et al., 2004). Thus, reducing SSIs and the complications secondary to them by a small amount would have a large reduction in the cost of the treating the SSIs (Cheadle, 2006).

Despite advances in knowledge and technology, as well as better sterilization techniques, SSIs remain a significant contributor to postoperative morbidity and mortality. This may be due to resistant microbes and increased numbers of elderly patients who are more susceptible to chronic debilitating and immunocompromising diseases (Mangram et al., 1999). SSIs are the most common nosocomial infection (Emoril & Gaynes, 1993), with the CDC estimating that up to 500,000 surgical patients develop SSIs each year (Cheadle, 2006). The reported range of SSIs is estimated to be 2-3% of all surgical cases, but the actual percentage is suspected to be higher. The VA has been tracking SSIs for many years and is considered the most proficient at tracking SSIs in their national patient population. They report an annual SSI incidence of 5.1%. This percentage applied to the greater national surgical population places the potential incidence of SSIs as high as 750,000 (Cheadle, 2006).

Evidence for Antibiotic Prophylaxis

Historical Perspective

Ignaz Philipp Semmelweis was one of the pioneers in the mid 1800s who revolutionized medicine by improving the understanding and avoidance of surgical infections. Although many discoveries and breakthroughs have been made, SSIs continue to place a major burden on surgical patients, surgeons, and hospitals (Hope et al, 2007). Prior to the 19th century, patients receiving a surgical operative procedure commonly encountered what was referred to as ‘irritative fever’, followed by drainage from their incisions, sepsis, and usually death.

It was Joseph Lister who pioneered the principles of antisepsis and made the substantial reduction in postoperative infectious morbidity possible (Mangram, Horan, Pearson, Silver, & Jarvis, 1999). Preoperative antimicrobials were found to be effective in reducing SSIs in experimental incisions on animals (Burke, 1961). The efficacy of prophylactic antibiotics in reducing the risk of an SSI was first demonstrated in animal and clinical studies throughout the 1960s (Polk & Lopez-Mayor, 1969).

In 1976, it was noted by researchers that antibiotics administered within one hour of surgical incision reduced post operative wound infection rates maximally (Stone et al., 1976). This study found no appreciable difference (i.e. 4% if 8-12 hours before vs. 3% if 1-hour before) as to when the antibiotic was given, as long as it was given preoperatively. These data would later be used to develop the prescriptive guidelines used by advisory groups today (Bratzler & Houck, 2004).

Preoperative Prophylaxis Guidelines

The Surgical Care Improvement Project (SCIP) is a national health care quality improvement initiative with the stated goal of reducing surgical morbidity and mortality by targeting several components of surgical care, one of which is the timely administration of preoperative antibiotics (Hope et al., 2007). While the role of proper antibiotic prescription and discontinuation lies in the hands of the surgeon, anesthesia providers have a valuable role in its initial timely administration.

Bratzler and Hunt (2006) delineate guidelines formed from the SCIP and from the Surgical Infection Project (SIP). They summarize the incidence of SSIs on a national level as well as the complications that ensue. In addition, they describe the process of developing the basic performance measures that are used today in national quality initiatives to benchmark quality measures reducing postoperative morbidity and mortality. These include the proper timing of antibiotic administration, the administration of the proper antibiotic as advised by national guidelines (depending on the surgery type), and the proper discontinuation of the antibiotic 24 hours afterwards.

Proper prophylactic antibiotic administration reduces the incidence of SSIs, reduces hospital stay length, and mortality (Davey et al., 2005; Webb, Flagg, & Fink, 2006). Others have confirmed the importance of maximizing the efficacy of the preoperative antibiotic by administering it 60 minutes prior to the surgical incision (Bratzler & Hunt, 2006; Scottish Intercollegiate Guideline Network, 2008). Bratzler and Hunt (2006) found on average preoperative antibiotics were administered 76% of the time. Of the times preoperative antibiotics were not given on time, more were given too early (18.7%) rather than too late (5.1%). Another interesting finding described that when anesthesia providers were responsible for administering the preoperative antibiotic, the likelihood of proper timing of the antibiotic administration was increased. The best performance of this measure involved the preoperative nursing staff preparing a preoperative antibiotic, and anesthesia services beginning the infusion after entering the operating room (Hawn et al., 2006).

Several advisory boards and government bodies have sought to reduce SSIs and the complications that accompany them. The authors participating in the Medicare National Surgical Infection Prevention Project (SIPP) produced consensus guidelines and formed an advisory statement that is the basis for national recommendations for antimicrobial prophylaxis in 1999. These included the type of recommended antibiotic for a specific surgery, administration of the antibiotic within one hour prior to surgical incision, and it's discontinuation 24 hours after the procedure (Bratzler & Houck, 2004). These guidelines are updated regularly as new evidence becomes available and is evaluated.

NSQIP was born out of need to improve outcomes in the Department of Veterans Affairs Hospitals (VA). It was tasked with evaluating and improving surgical outcomes on a national network to improve patient care for that population of patients that it served (Henderson, 2006). The purpose of NSQIP was to provide a reliable risk adjusted surgical outcomes data set so that surgical services and administrators in the VA health system could assess and compare surgical quality between medical centers (Henderson, 2006). Because SSIs are the most common postoperative complication, timely preoperative antibiotic administration is included as one of the quality measures in the NSQIP dataset. Since its inception in 1991 there has been a 47% reduction in 30 day postoperative mortality and 43% reduction in 30 day postoperative morbidity (Khuri et al., 2007).

Guidelines developed by experts in health care and professional health care provider groups are consistent and readily available to those who prescribe antibiotics. These guidelines revolve principally around prescribing the proper antibiotic prior to surgery, administering it in a timely fashion one hour prior to surgical incision, and discontinuation 48 hours after initiation (Hope et al., 2007; "Prohylactic antibiotics," 2003).

On-time Administration

Bratzler and Houck (2004) summarized the NSQIP recommended data for indicators that are surveyed nationally to measure quality outcomes. Observed to expected ratios of surgical quality indicators (one of which was the incidence of SSIs) to achieve an estimated predictive likelihood of morbidity and mortality were calculated. One of the measures that specifically pertains to the role of anesthesia providers is the timely administration of antibiotics preoperatively, measured as a percentage of timely delivery of preoperative antibiotics on a monthly basis for specific surgical cases, with exceptions noted for early administration and specifically not ordered. A strong recommendation was made to enhance the percentage of timely administration of preoperative antibiotics to reduce the occurrence of post operative surgical site infections. Their recommendations were to give the antibiotic one hour prior to surgical incision, except in the case of Vancomycin, which should be given up to two hours prior to incision.

The reason for the goal of timing the antibiotic administration at one hour prior to the surgical incision is for the purpose of dosing the agent so that a bactericidal concentration of the drug is established in serum and tissues by the time the skin is incised (Classen, et al., 1992). There is wide agreement that antimicrobial prophylaxis should be given 30-60 minutes before the incision is made to ensure that adequate tissue concentrations are present (Cheadle, 2006).

When antibiotics for surgical procedures are not given correctly, they are most often given too early (>60 minutes prior to surgical incision). Both late and early prophylactic antibiotic administrations are associated with increased SSI rates (Classen et al., 1992).

The baseline timely administration percentage of preoperative antibiotics for abdominal and vaginal hysterectomies in 2001, according to Medicare CMS data, was

55.7% (Bratzler & Hunt, 2006). Using a focused awareness initiative on maintaining quality indicators such as normothermia, euglycemia and timely antibiotic administration, a collaborative of hospitals with a baseline timely preoperative administration rate of 72% was able to improve by 15%, and reduce SSIs by 27% (Delinger, Hausmann, & Bratlzer, 2005).

Evidence for Behavior Change Through the Use of Electronic Feedback

Anesthesia providers have an opportunity to contribute to the reduction of SSIs by participating in timely administration of preoperative antibiotics when they are indicated. The importance of preoperative antibiotic administration has been reviewed. Literature pertaining to improving or changing the behaviors of health care providers will now be examined.

Quality timely documentation is an important mechanism by which providers can demonstrate appropriate intraoperative diligence to care (Sandberg et al., 2008). The use of computer guided decision support can enhance the performance of adherence to published health care delivery quality measures (Webb et al., 2006). Reminder systems have been effective in improving practices and compliance with published practice guidelines.

In general, reminders (alerts and notifications given in real time at the point of care event) are more effective than feedback (data given back to the provider or group after the event has taken place by days or weeks) (Bennett & Glasziou, 2003). Various methods of interventions have been used to improve health practice behaviors. Whatever type is used, they are most effective if they are presented close to the time of decisionmaking. Reminders embedded into electronic medical records alert providers regarding clinical information relevant to a targeted clinical task (Shojania et al., 2009).

Research suggests that tailored communication modalities change behavior because recipients respond favorably to the notion that informational material was made specifically for them (Kreuter & Holt, 2001). Personalization gives the perception of enhanced relevance to the recipient. Most research has focused on behavioral response variables to tailored communication. Future research will investigate the effect of individual learning style, as well as the style of information presentation on effectiveness of behavior change (Kreuter & Holt, 2001). Successful interventions to effectively change clinical practice are sufficiently persuasive and relevant to the population for which the intervention is intended for. This can be done by tailoring messages to the individual intended recipient (Gagnon et al., 2009).

Computer reminders achieve improvements in process adherence, process outcomes, and process measures (Shojania et al., 2009; Zanetti, Flanagan, Cohn, Giardina, & Platt, 2003). Point of care computer reminders achieve small to modest improvements in provider behavior, but there is no specific type of reminder that achieves a larger effect on the health care provider population.

Decision support tools and internet based technologies and services are two broad categories of communication technologies used in health care today. Computerized reminders have shown benefits for health care systems and may improve patient outcomes. Patients are supportive of the use of information communication technologies by clinicians (Gagnon et al., 2009).

Text message reminders delivered to individual anesthesia providers produced nearly a fourfold reduction of their documentation error rate in the study by Sandberg et al. (2008). The reduction was achieved within days of the intervention. When the message was delivered to the clinician during the case, and if an error was committed, the message was found to be effective in influencing the provider to correct the error during the case. Improvement in documentation on the anesthesia record persisted two months after the intervention was suspended (Sandberg et al., 2008).

Text messages and on screen alerts as a method of sending reminders is a momentary distraction and more acceptable in the operating room (OR) environment, allowing the provider to respond when appropriate (Healy, Servdalis, &Vincent, 2006). Although simply forcing providers to correct the documentation before proceeding further (referred to commonly as a hardstop) would be more efficient, it was judged to be too restrictive and distracting from caring for the patient (Sandberg et al., 2008). A hard stop reminder in the EARK forces a change in current tasks of the provider requiring immediate action that is perhaps directed away from more critical patient care activities at the time the alert is received (Healy et al., 2006).

Webb et al. (2006) measured timely antibiotic administration on a monthly basis. To improve their antibiotic administration, researchers implemented electronic prescribing reminders to the surgeons and changed the process of administration to be delivered by the anesthesia provider in the operating room. The interventions improved the timely administration of preoperative antibiotics from 51% to 95% after five months (Webb et al., 2006).

The underlying technology used in an EARK allows customized software to search for a specific indicator that can trigger the generation of a message or alert. Using customized software to work with an EARK can be useful in identifying inconsistencies in documentation of the anesthesia record suspended (Sandberg et al., 2008).

Equipped with the knowledge of the proper practice of administering preoperative antibiotics in a timely manner, efforts to improve the performance of this task to ultimately improve patient outcomes have been undertaken. In a multidisciplinary approach that included anesthesia personnel, barriers to properly administering the preoperative antibiotic and examined processes that lead to the highest proportion of patients receiving the antibiotic in a timely manner were identified (Webb et al., 2006). Among the solutions implemented were the use of an electronic ordering system to enhance the timeliness of pharmacy preparation and delivery.

Building on the use of electronic systems to enhance patient care and outcomes, Franklin et al. (2006) examined the use of frequent email reminders to change the behavior of health care providers. They concluded the use of electronic messages to participants was effective in promoting lasting changes in participants' behavior patterns, and that such a system was feasible to deploy in many health care environments. In a study of an electronic reminder to anesthesia staff using an electronic documenting system, Wax et al. (2007) observed improvements on the proportion of patients receiving timely preoperative antibiotics. They also noted the improvements were long term and lasting.

A meta-analysis of 16 randomized clinical trials evaluating the use of electronic reminders employed to change prescribing practice behaviors of health care providers in the acute care setting was performed (Shea, DeMouchel, & Bahamonde, 1996). Manual paper reminders, in addition to electronic reminders, were as effective as electronic automated reminders alone in positively changing the antibiotic usage practice behaviors of health care providers. Tables 2.1 and 2.2 provide summary of the evidence with respect to electronic feedback mechanisms.

Table 2.1

Summary of Evidence on the Effect of Electronic Reminders Change Practice Behaviors

Reference study	Process addressed	Feedback method	Maximum observed effect
Sandberg et al. (2008)	Documentation of clinical events (patient allergy data used as test case)	Automatic alphanumeric page to clinician signed into AIMS as performing the case	Fraction of records missing allergy documentation fell from 31% to approximately 8%
Wax et al. (2007)	Documentation of routine prophylactic Antibiotic administration prior to incision	Pop-up window in AIMS display	Raised aggregate compliance with timely documentation of routine antibiotic prophylaxis from 82.4% to 89.1%; raised compliance among those acknowledging the alert from 82.4% to 93.4%
O'Reilly et al. (2006)	Documentation of preoperative prophylactic antibiotic administration	Personalized e-mail to individual clinicians	Fraction of eligible patients who received antibiotic prophylaxis within 1 h before incision rose from 69% to 92%

From: "Real- Time Checking of Electronic Anesthesia Records for Documentation Errors and Automatically Text Messaging Clinicians Improves Quality of Documentation," by W. Sandberg et al., 2008, *Anesthesia and Analgesia*, *106*, p. 198.

Table 2.2

Critical Appraisal Table of Relevant Literature concerning electronic feedback mechanisms

Author	**Study type (electronic feedback mechanisms)**	**Summary**
Davey et al. (2005)	Meta-analysis of 66 RCT, CBA and ITS studies describing interventions to improve hospital based antibiotic prescribing behaviors and performance.	Many different methods are effective to increase the appropriate use of antibiotic use in the hospital setting. Prompt and timely administration of antibiotics yields favorable clinical outcomes.
Wax et al. (2007)	Retrospective review of electronic anesthesia records. PRE/POST intervention Well designed RCT	Visual interactive reminders regarding preop antibiotic administration significantly improved and had lasting effects.
Webb et al. (2006)	Controlled Trial without randomization	1. Implementing an electronic reminder to the anesthesia provider improved the rate of on time preop abx administration
Shea et al. (1996)	Meta-analysis of 16 RCT	Electronic Reminders were as effective as electronic and manual reminders in changing the prescribing practice of heath care providers
Franklin et al. (2006)	Controlled Trial without randomization	Electronic communication is an effective and feasible means of promoting lasting behavioral change amongst health care workers

CHAPTER THREE: METHODOLOGY

This chapter presents a description of the design, sampling and methodology for the study, followed by a discussion of the data collection parameters. Finally, a detailed description of the data flow is presented.

Study Design

This study employed a retrospective one-group before and after design. It examined the influence of electronic reminders on the timely administration of preoperative antibiotics by anesthesia personnel.

Sample and Setting

The sample was comprised of anesthesia providers at a medium-sized academic medical center in the United States. All anesthesia providers consenting to participate were included. The hospital has 25 anesthetizing locations and conducts about 12,500 surgeries every year.

Methods

The purpose of the study was explained and participation was solicited during anesthesia department meetings prior to the beginning of the study. Those who chose to participate completed a demographic data questionnaire where age in years, gender, years of experience giving anesthesia, and years of experience using an electronic anesthesia record were collected. Those providers who chose to participate signed a written consent. This study was approved by the institutional review boards of the University of North Florida and the hospital where the data where gathered.

Using an Electronic Anesthesia Record Keeping (EARK) system, information concerning preoperative antibiotic administration was extracted from an existing database for all surgical procedures during a 42 week period. This 42 week period was divided into three phases. Phase 1, weeks 1-20, was the period in which data were accumulated prior to any intervention and thus served as the control data set.

Phase 2, weeks 21-36, was the period in which a software application displayed preoperative antibiotic on time percentage data for the department every 18 seconds. The on time percentage data alternated between daily, weekly, and monthly time periods for the calculated on time percentage displayed on the screensaver. The software application displayed the data on a screensaver that was placed on a large monitor in a high traffic area frequented by members of the anesthesia department.

Phase 3, weeks 37-42, was a period in which the software application delivered both the individual’s on time percentage and the department’s on time percentage in the form of an SMS text message to each individual provider. The text messages were sent on the same day and time each week in phase 3. The on time percentage was calculated over a seven day period for the preceding week. The anesthesia providers were only able to see their own individual on time percentage and that of the department as a whole for the preceding seven days.

Input Data Requirements

The following section will outline and explain the requirements for data input in this research study. Processes and events required for the administration of antibiotic will be categorized as human factors. Equipment and systems technology needed for the input of the data will be discussed in the device factor requirement section.

Human Factor Requirements

The anesthesia provider must first receive either a verbal or written order to administer the antibiotic preoperatively from the surgeon. Once the order is received, the antibiotic must be administered, and then documented on the EARK. All participating anesthesia providers received training in the proper documentation utilizing the EARK. This included the mechanism of documenting exceptions for when an antibiotic should not be given or was not ordered. Examples of this would include cases when the patient was already receiving an antibiotic regimen, or when a specimen culture must be obtained from a wound during the surgery prior to an antibiotic being administered.

Device Factor Requirements

Documentation using an EARK requires a computer workstation with electronic anesthesia record keeping software. In this study, a workstation was mounted on the right side of each of the anesthesia machines and was easily accessible by the anesthesia provider during operations.

Processing

Global Data Flow Overview

Figure 3.1 shows the flow of information through the process. The process starts in the operating room when an anesthesia provider uses the EARK workstation to log a surgical event took place. This event can be a range of actions such as noting that the patient has entered the room, logging the administration of an antibiotic medication, or noting a surgical incision. The event, the user who entered the event, the time of the event, and the time the event was entered are stored in a large database table that is part of the EARK. Other information about the operation, the staff member who initiated the logged action, and the patient's visit to the medical institution are also stored in the EARK database.

EARK Database Input Tables and Input Screens

The leftmost entity on Figure 3.1 is the EARK input screens. These are the screens that an anesthesia provider uses to enter information into the EARK system. This information is stored in various tables within the EARK system's database (see Appendix). These tables are comprised of the "staff," "operations," "iopdata," and "visits" tables.

Input Screens

Figure 3.2 shows a system input screen where a user is able to enter surgical events. This listed information on the screen is stored in the "iopdata" table.

Input Tables

Staff table. The staff table holds general information about the different system users (anesthesia providers) at the medical institution including name and employee identification number. This table is used to provide the names and other descriptive information about the anesthesia providers. The primary key in this table was the 'staff_sys' column

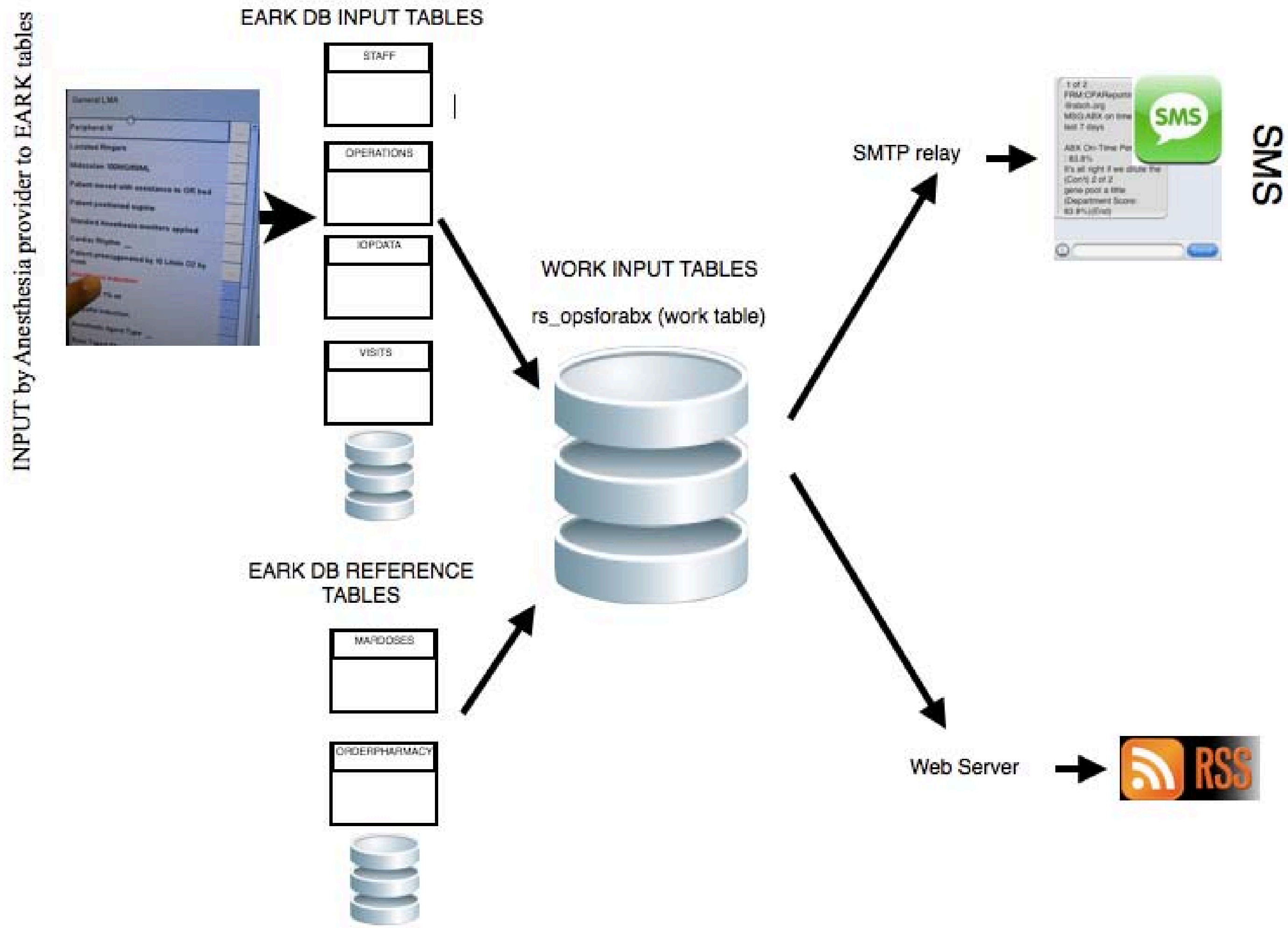

Figure 3.1 Overall dataflow including utilized methods of data delivery.

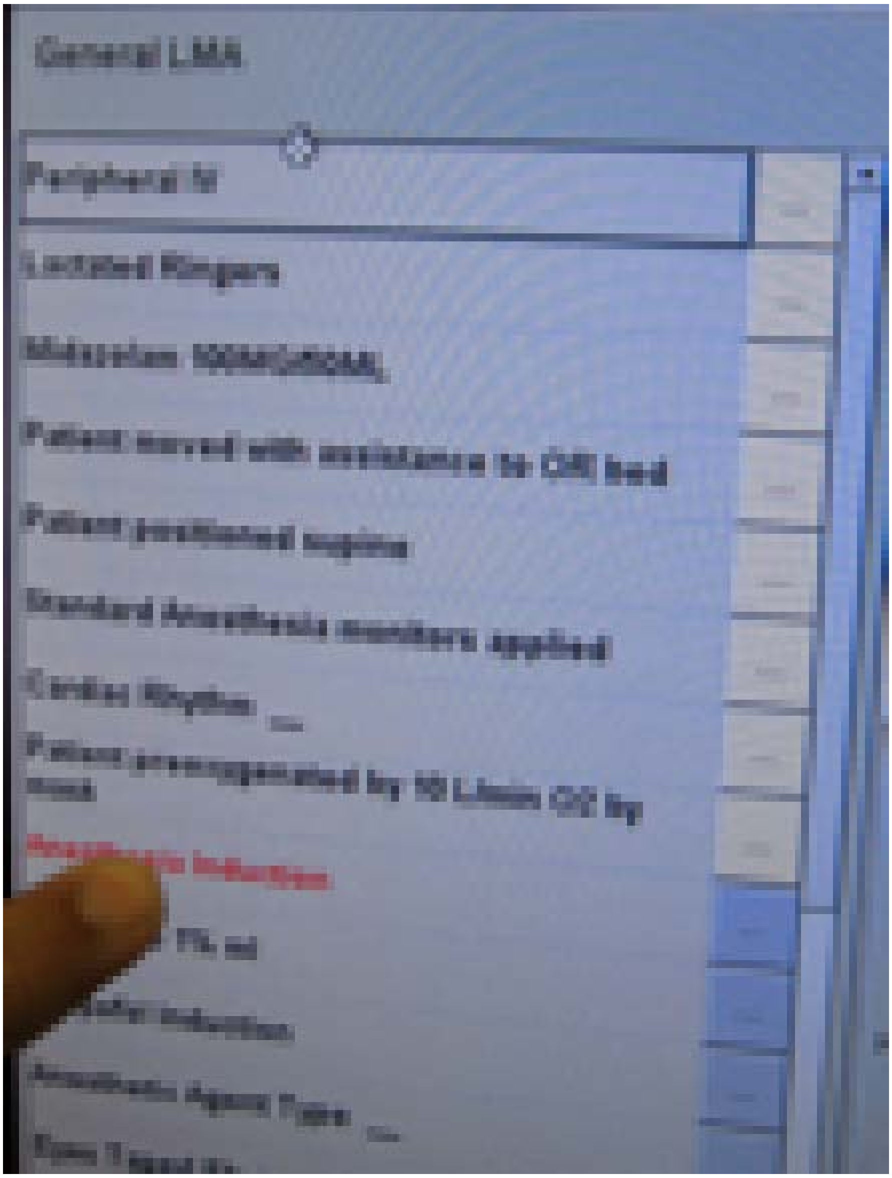

Figure 3.2 Photo of an anesthesia provider inputting data into the EARK via touch screen which is stored in the EARK database table "iopdata".

The staff table (see Table 3.1) was used to correlate userstamp information to deliver data in SMS text message. This was used to extract data from the anesthesia record database to fill the temporary data table for agent or user report processing and calculation.

Table 3.1 "Staff" Table (primary key underlined)

Table Column Name	Description
<u>staff_sys</u>	Record keeper's staff identifier
name_last	Clinician staff member's last name
name_first	Clinician staff member's first name
staff_type	Documentation staff type (anesthesiologist, certified registered nurse anesthetist, registered nurse, etc.)
uid	Hospital's staff Identification. It was used to track who was logged in when a documentation entry was made.
discipline	Staff worker type (surgery, anesthesia, quality assurance)

Operations table. This table holds general information about each procedure performed at the medical institution including the procedure date. The procedure date is used to filter operations when evaluating performance over a certain period of time (eg. The last six months, three months, the last seven days). The the 'op_sys' column is the primary key used for relating the table data and is underlined in Table 3.2.

Visits table. This table holds general information about each patient's trip to the hospital. It relates to the operations table as well as the final input table iopdata. The primary key was the visit_sys column.

Table 3.2 "Operations" Table (primary key underlined)

Table Column Name	Description
<u>op_sys</u>	Electronic anesthesia record keeper's surgical procedure identifier
visit_sys	Record keeper's visit ID
date	Date of operation
attending_sys	Record keeper unique ID for scheduled surgeon
ssi_op_id	Identifies the medical institution's unique operation

The visit table was used by the software to relate table structures to each other (see Table 3.3). By using column primary keys to relate to different tables, one can relate those tables to each other, and identify information that is split between tables that relate to the same anesthetic case data for the patient. For example in the partial intraoperative data table shown in Table 3.4, the columns 'patient_sys' and 'visit_sys' can be related to the columns in the visit table (see Table 3.3) as they are common to both tables. By relating the tables using this methodology, the software can then collect data needed by the reporting agent such as admit date (which is not contained in the partial "iopdata" table) because it is contained in the "visit" table.

Iopdata table. This table contains the bulk of the inputs used for this study. It contains every event that took place during any surgical procedure at the medical institution. It contains a description of the surgical procedure's events, the time

Table 3.3 Partial Listing of "visit" Table (primary key underlined)

Table Column Name	Description
patient sys	Recordkeeper's patient ID
visit num	Hospital's patient ID
visit_sys	Record keeper's visit ID

Table 3.4 Partial Listing of "iopdata" Table (primary key underlined)

Table Column Name	Description
patient sys:	Recordkeeper's patient ID
visit sys:	Recordkeeper's visit ID
subvisit sys	Not Used
op sys	Recordkeeper's operation ID
enteredby sys	Staff Member who entered the event
date observation	Time the event took place
date entered	Time the event was entered
date deleted	If the event was later deleted, time it was removed
deletedby sys	If the event was later deleted, person who deleted it
current value	Is the event currently valid
value	Text string describing the event
iopdata sys	Table identity

the event was observed, the time it was recorded and the anesthesia provider who recorded the event. This table can be queried for the times of surgical incision as well as any antibiotics that were delivered, which in turn allows the determination of whether or not antibiotics were given appropriately for any particular surgery.

The intraoperative data table contains a listing of events, timestamps, and userstamps data of every operative event documented in the electronic anesthesia record by the anesthesia provider during the conduct of the anesthetic (see Table 3.3).

EARK Datbase Reference Tables

The following section will outline the reference tables illustrated in Figure 3.1. One was used as a drug crossreference lookup table, and the other a type of temporary work table that stores various pieces of data needed to perform the calculations for timely administration and other functions.

Reference Tables

Mardoses. This table contains a recording of the doses and the name of a drug that is recorded in the iopdata table. If an antibiotic was administered and documented by the provider, this table is referenced to gather other information about the drug such as the drug system number to relate via a primary key to the orderpharmacy table. The primary key of the “mardoses” table was the ‘dose_sys’.

The EARK database utilized the “mardoses” table with information specific to medications administered to a patient during the anesthetic (see Table 3.5). When the report indicated a dose of antibiotic was given, further information were gathered from this location in the database and integrated into the complete data set contained in the "rs_opsforabx" table.

Orderpharmacy. This table contains the therapeutic class information which the system will use to evaluate whether a medication identified in the mardoses table is an antibiotic. It is a performed to ensure that medications that are new antibiotics are

Table 3.5 "mardoses" Table (primary key underlined)

Table Column Name	**Description**
profile_sys	Identified the dose within the system then related back to the IOP data_sys column in the intraoperative data table
<u>dose_sys</u>	Identity of the drug (antibiotic)
med_sys	Anesthesia record keeper drug identifier definition. This was used to relate to a separate column of user defined drugs.
userstamp	Used to relate to staff table identical column
timestamp	Used to relate to staff table identical column

included for analysis. The primary key for the "orderpharmacy" table was the 'drug_sys' column. The "orderpharmacy" table (see Table 3.6) contained a listing of all the registered medicines defined in the system. Included in this table were alternate names of those medications, as well as a classification assigned to the medication. This classification was a fail-safe design by the vendor to allow for the inclusion of new antibiotics when they were put into the system by the electronic anesthesia record keeper software administrator. This allowed for the automatic inclusion of newly released antibiotics by the pharmacy and reduced the dependence of the IT software administrator on the pharmacy to be notified of the new inclusion. If a new drug was to be introduced to the system, it would be easily identified in the system, thereby including it in the calculations for on time antibiotics.

Work Table

The middle section of Figure 3.1 describes the work table. The input data needed by this study is stored across 4 disparate tables. One of the central steps of the data flow

Table 3.6 Partial Listing of "orderpharmacy" Table (primary key underlined)

Table Column Name	**Description**
drug_sys	Electronic anesthesia record keeper's drug identifier
dea_class	Identifies the type of medication (antibiotic)

is to reorganize all of the input data, filter it based off of reference tables that already exist within the EARK system. This data is then stored it in a work table that contains one row per operation along with all the pertinent information. This work table then allows the determination of the success or failure of antibiotic delivery for any given operation or series of operations. This, in turn, simplifies the process of generating outputs based on a variety of filters and is represented on the right side of Figure 3.1.

The work table is named "rs_opsforabx" and was located in the EARK database. Each row within the "rs_opsforabx" work table contains a single line for each operation

performed along with information about the anesthesia provider, the surgical incision time, and the antibiotic delivery time(s). Since transforming the information from input and reference tables into the "rs_opsforabx" table is critical to determining the success or failure of antibiotic delivery, a discussion about how it was filled will follow. Figure 3.3 is an entity relationship diagram that illustrates the associations between the input tables, the references tables, and the work table.

The process for generating the work table “rs_opsforabx” and transforming the data from inputs to the work table will now be described in the algorithmic procedure in Figure 3.4.

First, the “rs_opsforabx” table is cleared in preparation of a new data set. This is illustrated in line one of Figure 3.4. Line three shows the operations table being joined to the “staff”, “visits”, and “iopdata” tables. These tables are all joined by the primary key in each table which is referenced in Figure 3.3. Each event contained in the “iopdata” table is now filtered down to an event entitled ‘surgical incision’. This process filters out all of the procedures that may be stored within the institution’s EARK database that weren’t actual operations, and therefore have no bearing on the calculation of the institution’s on time antibiotic delivery percentage metric. The “operations” tables’ identity (op_sys), the medical institution’s operation number (ssi_op_id), medical institution’s visit number (visit_num), information about the anesthesia provider (‘anes_staff_sys’, ‘anes_name_last’, ‘anes_name_first’, and the time of ‘surgical incision’ (‘date_observation’ from the “iopdata” table) are then inserted into the rs_opsforabx table and this is illustrated on line six in Figure 3.4.

By default, all operations where there was a surgical incision are considered to need antibiotics, so the NeededABX value is set to true on each row inserted into the “rs_opsforabx” table. The next step performed is to clear the NeededABX bit for all operations that are deemed to not need antibiotics. This is done by looking for

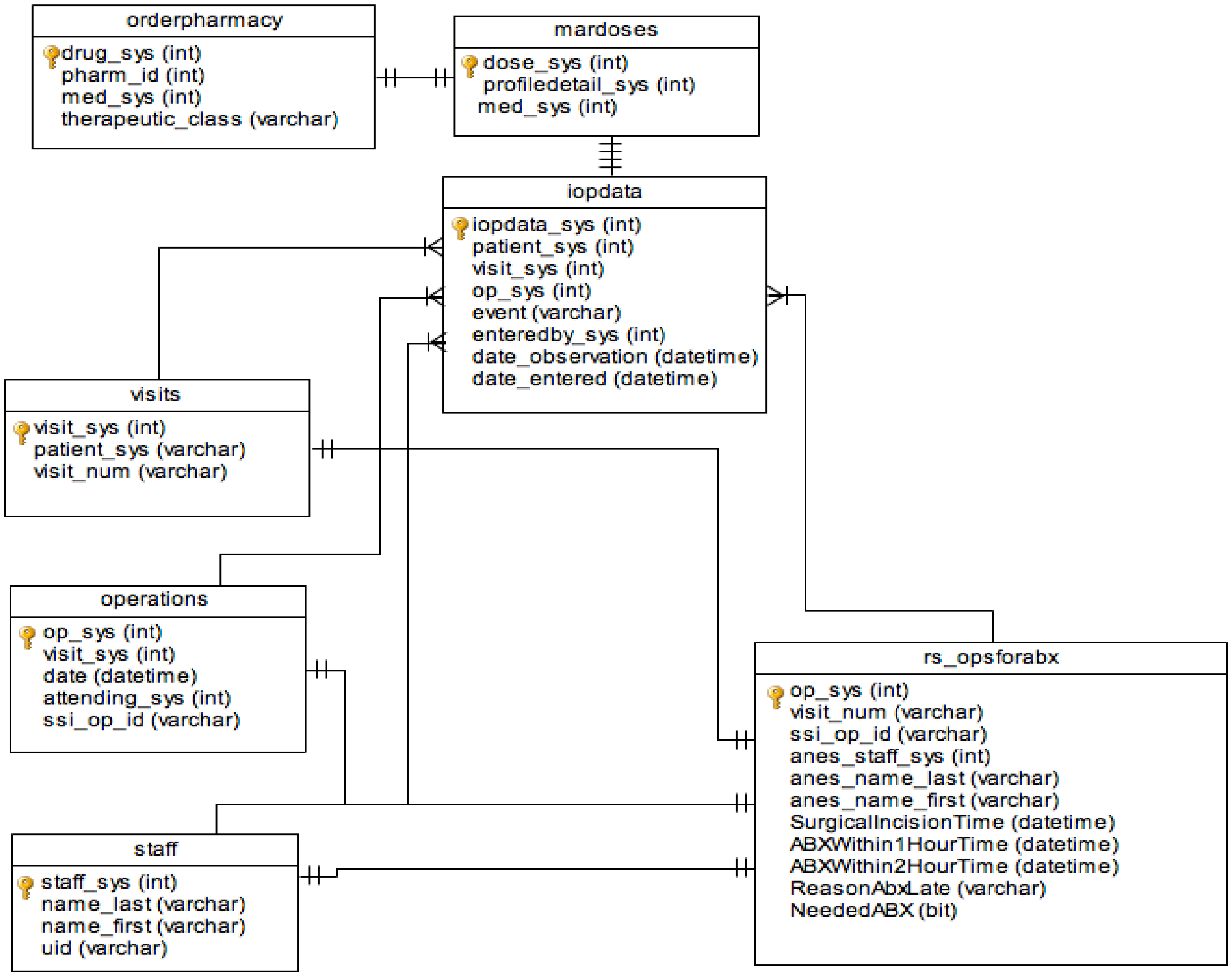

Figure 3.3 Entity Relationship diagram for input, reference, and work tables.

```
1.  delete all rows from the rs_opsforabx table
2.
3.  select from operations table joined with staff, visits, and iopdata
4.  where the iopdata event = "Surgical Incision"
5.
6.  insert input table keys from this resultset into the rs_opsforabx table
    along with NeededABX = 1 and SurgicalIncisionTime = iopdata's date_observation
7.
8.  update rs_opsforabx set NeededABX = 0 where op_sys in
9.           (select op_sys from iopdata where event  like '%PQRI 2672%', 2673, etc. )
10.
11. update rs_opsforabx set ABXWithin1HourTime =
12.       (select min(date_observation) from iopdata for the same operation
13.        joined to orderpharmacy and mardoses tables  (iopdata_sys = med_sys)
14.        where the drug given had a class = "1 hour Antibiotic" )
15.
16. update rs_opsforabx set ABXWithin2HourTime =
17.       (select min(date_observation) from iopdata for the same operation
18.        joined to orderpharmacy and mardoses tables  (iopdata_sys = med_sys)
19.        where the drug given had a class = "2 hour Antibiotic" )
20.
21. Update rs_opsforabx
22.      set ReasonABXLate = "Not Given" when ABXWithin1Hour is null and ABXWithin2Hour is null
23.      set ReasonABXLate = "1 Hour ABX Given Too Early" when ABXWIthin1Hour is not null and
24.           ABXWithin1Hour is before (an hour before surgical incision)
25.      set ReasonABXLate = "2 Hour ABX Given Too Early" when ABXWIthin2Hour is not null and
26.           ABXWithin2Hour is before (two hours before surgical incision)
```

Figure 3.4 Code snippet detailing work table generation and data transformation in work table.

specific events within the iopdata table for each of the operations currently held within the "rs_opsforabx" table. Some specific types of surgery (such as eye surgery) don't require antibiotics and may be eliminated from analysis based on a documentation event entered by the anesthesia provider that indicates the surgery should not be included in the calculation. This update is shown in an abbreviated form on lines eight and nine of Figure 3.4.

Lines 11 through 19 of Figure 3.4 show queries made to the EARK database to retrieve the exact times that antibiotics were given. Two different types of antibiotics were retrieved in the query: antibiotics that should be given within one hour of the time of surgical incision and also antibiotics that should be given within two hours of the time of surgical incision. Most antibiotics fall into the former category while Vancomycin is an example of the latter.

The “iopdata” table is joined to the table that stores a record of all medications issued during an operation (“mardoses”) and then further joined to the table that stores the therapeutic classification of the medication (“orderpharmacy”) This is necessary to determine which drugs retrieved in the query were antibiotics and into which category of antibiotic they fell (one hour, or two hour). The “rs_opsforabx” table is then updated with the antibiotic administration times retrieved from this query.

Finally, with all the raw data collected and filled into the table, a stored procedure checks each row to see if the antibiotics were administered within the appropriate time window and, if not, updates the ReasonAbxLate field with text explaining the problem. This free form explanation is only seen on the Microsoft Excel report since the other reports aggregate the data to provide summary information). This logic is shown on lines 21 through 26 in Figure 3.4.

Once the above algorithm has run its course, the rs_opsforabx is now filled and ready to be used in the generation of the outputs used in this study which are represented on the right side of Figure 3.1. An example of the work table loaded with records is shown in Figure 3.5.

The data in Figure 3.5 is representative of a typical output data set during the study. Entries with the value of ‘NULL’ indicate there was no data contained in the table for that record and column. It can indicate that an antibiotic was not documented for the surgical procedure (it does not indicate the antibiotic was not given, only that it was not documented). The first operation record shows the anesthesia provider Sam Smith correctly administering antibiotics to his patient. The surgery needed antibiotics, the incision occurred at 6:12 AM and a standard one hour antibiotic type was administered at 6:03 AM. The anesthesia provider, identified as Dan Doe on record two, is an example of an inappropriate antibiotic administration. A one hour antibiotic type was administered at 5:15 AM. The incision did not occur until 6:22 AM. This example represents a missed antibiotic administration. If the surgery had started earlier, the antibiotic administration would have been considered timely. In the second example described, the antibiotic was given too early. Note that in surgeries three, six, and seven, there is no antibiotic given. This is appropriate for surgeries six and seven since it is also indicated that antibiotics were not needed. The operation listed on row three, however, required antibiotics but the patient did not receive any. This surgery will be counted against the provider (Sam Smith) on reports about his on-time performance on that date.

Output Data Calculation

Once the rs_opsforabx work table has been populated, information is aggregated into a single score. The results shown in Chapter Four will show antibiotic delivery on-time percentages for various ranges of time (such as a specific two week time period) for the department as a whole.

op_sys	visit_num	ssi_op_id	anes_staff_sys	anes_name_last	anes_name_first	SurgicalIncisionTime	ABXWithin1HourTime	ABXWithin2HourTime	ReasonAbxLate	NeededABX
1	3137	O31K2L	37827	Smith	Sam	1/1/09 6:12 AM	1/1/09 6:03 AM	NULL	NULL	1
2	3139	O23J6T	38372	Doe	Dan	1/1/09 6:22 AM	1/1/09 5:15 AM	NULL	1 Hour ABX Given Too Early	1
3	3145	O66Q9V	37827	Smith	Sam	1/1/09 9:03 AM	NULL	NULL	ABX Not Given	1
4	3146	O92K7R	34901	Brown	Bernice	1/1/09 9:08 AM	1/1/09 8:41 AM	1/1/09 7:10 AM	NULL	1
5	3147	O19M2M	37827	Smith	Sam	1/1/09 12:05 PM	1/1/09 11:00 AM	NULL	1 Hour ABX Given Too Early	1
6	3162	O38P2R	38372	Doe	Dan	1/1/09 12:15 PM	NULL	NULL	NULL	0
7	3164	O91L4M	37827	Smith	Sam	1/1/09 3:01 PM	NULL	NULL	NULL	0
8	3167	O18L11T	37827	Smith	Sam	1/2/09 9:40 AM	1/2/09 8:41 AM	1/2/09 7:28 AM	2 Hour ABX Given Too Early	1
9	3169	O19V9X	38372	Doe	Dan	1/2/09 9:10 AM	1/2/09 9:10 AM	NULL	NULL	1

Figure 3.5 The “rs_opsforabx” work table once it has been filled with data. (The data contained above is sample data)

The rs_opsforabx work table is filtered down to only the rows whose surgical incision falls within any date range filters and whose anesthesia provider is appropriate. For instance, if a report requested antibiotic information for Dan Doe on January 1st, then just operations two and six would be viewed. A report for Sam Smith without a date range would be based on operations one, three, five, seven and eight. The on-time percentage is calculated by counting the number of these rows that had NeededABX and had no ReasonABXLate divided by the total number of rows that NeededABX. A SQL query used in the generation of our outputs is shown in Figure 3.6. The 'anes_staff' number 37827 correlates with a specific anesthesia provider in the Figure 3.5.

```
select count(*) from rs_opsforabx
where anes_staff_sys=37827
and NeededABX is null
and ReasonABXLate is null
and SurgicalIncisionTime between '1/1/09' and '2/1/09'
/
selct count(*) from rs)_opsforabx
where anes_staff_sys=37827
and NeededABX is null and SurgicalIncisionTime between '1/1/09' and '2/1/09'
```

Figure 3.6 SQL query used to generate percentage output calculations for timely antibiotic administration for a single provider (in this example it is keyed in the staff table as number 37827) for one month (in this example is is January of 2009).

Output Types

There were two different outputs utilized for this study. SMS text messages were sent to anesthesia providers' cell phones at pre-scheduled times. An RSS feed was kept up-to-date on an internal server and that RSS feed was accessed and displayed visually on a large 30 inch LCD display by a computer in the anesthesia break room. These outputs were both driven by a separate agent process that ran as a service on an internal web server at the study's site. This process would check periodically to see if an SMS message had been scheduled for delivery or if the RSS feed's data was more than 15 minutes old. If an SMS text message report was needed, or if the RSS feed was stale, the agent process would call a stored procedure to refill the work table (according to the pseudo code provided above, in Figure 3.4) and then generate and publish the appropriate output. The following discussion will describe the outputs illustrated earlier on the right side of Figure 3.1.

SMS Text Message Output

The outputs for SMS text messages were processed and sent out every Tuesday at 10:00AM during phase 3 of the study. The SMS text messages contained two pieces of information. The first part informed the participant of their own antibiotic on time percentage calculation for all eligible cases they documented on in the EARK for the prior seven days. The second part detailed the calculated percentage for all eligible cases performed by all anesthesia providers who documented in the EARK for the same time period. An example of a typical SMS text message is shown in Figure 3.7.

The agent process would generate an email message for each anesthesia provider that had an operation within the past week. This email message was then sent to an email address at their cell phone provider's domain which transformed it into an SMS text message for delivery to their cell phones. The agent used an SMTP server that was accessible from the internal network was used to send these messages. Figure 3.8 shows the SMS agent's source code (in C#) that creates the SMS text message to a provider's cell phone. Lines 1 and 2 form a .NET email message, 4 through 7 assign the recipients,

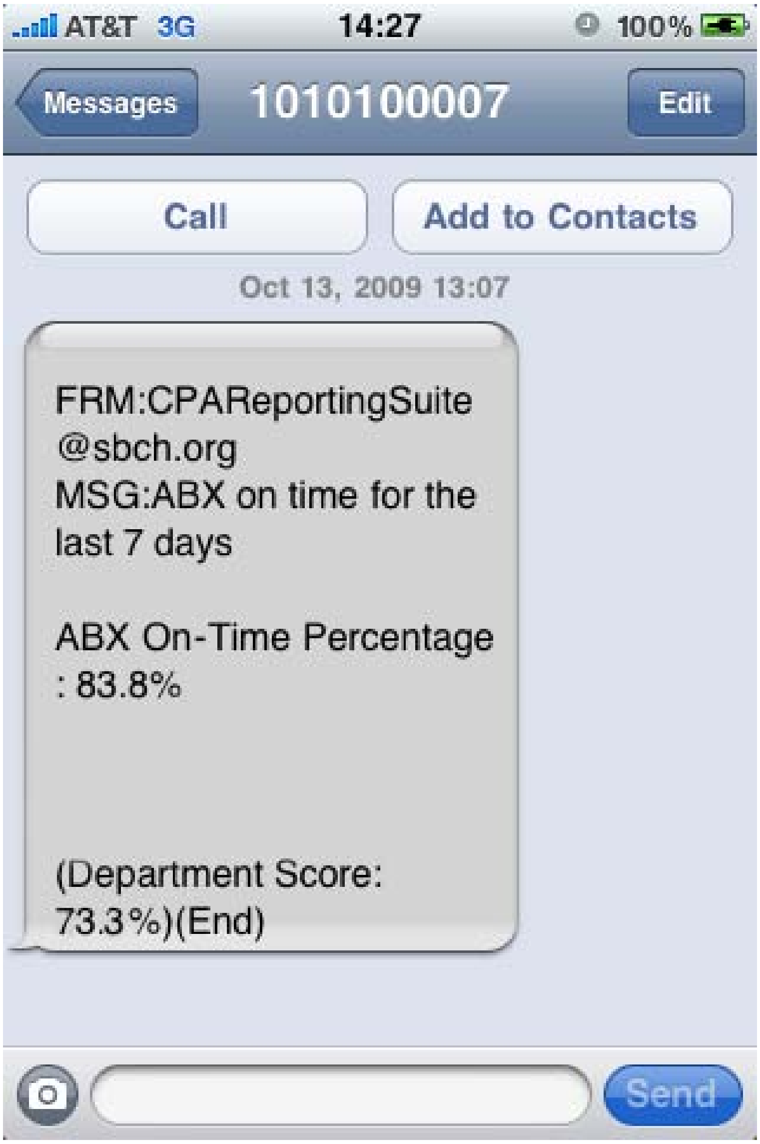

Figure 3.7 An example SMS text message received by an anesthesia provider.

and lines 10 through 14 create the body of the message using the aggregate scores that were queried from the work table using a SQL statement such as the one illustrated in Figure 3.6.

```
MailMessage mm = new MailMessage();
mm.From = new MailAddress(settings.SenderAddress);

foreach (string recipientAddress in
schedreport.outputparameter.Split(‘;’))
{mm.To.Add(new MailAddress(recipientAddress));
}

//the next section sends an SMS comparing the
requesting participants’s value to the department score
mm.Body = gaugeRow1.name+ “ : “+formattedValue1;
mm.Body += “\r\n” +  scoretext1;
mm.Body += “\r\n(Department Score: “ +
formattedDepValue1 + “)”;
```

Figure 3.8 Creation of the SMS text message.

RSS Feed Screensaver

The source of the RSS feed is an XML document located on a web server on the work site’s internal network. This XML document is kept up to date by the same agent process that is responsible for sending out the SMS text messages. Much like the procedure for sending out the SMS message, the first step the agent takes is to determine if the output is needed. In the case of an SMS text message the output is needed if the SMS text message is scheduled for delivery to a recipient. In the case of the RSS feed, output is considered necessary if it has been 15 minutes since the RSS’ source XML file is more than 15 minutes old. If the XML file that drives the RSS feed is more than 15 minutes old then the agent process considers it to be stale and will regenerate the XML on the web server. Assuming that the feed does need to be refreshed, the agent will call the same stored procedure to update the work table with the latest information and then will write out a new XML file using that data. Figure 3.9 below shows an XML file that has been created to drive the RSS feed. Each item within the RSS feed is an aggregate of antibiotic delivery from the work table for all users over different ranges of time.

```
XML file created to serve as an RSS feed.
<?xml version=”1.0”?>
<rss xmlns:media=http://search.yahoo.com/mrss/ version=”2.0><channel>
<title> CPA Reporting Suite Feed</title>
<link>http://www.hospitalsname.org/test.xml</link>
<descrption> A collection of internet feeds and hospital statistics.</description>
<language>en-us</language>
<lastBuildDate> Sat, 16 May 2009 11:13:49 GMT</lastBuildDate>
<pubDate> Sat, 16 May 2009 11:13:49 GMT</pubDate>
<item>
<title> ABX OnTime % For Month</title>
<description> 70.84% of antibiotics have been delivered ontime.</description
<pubDate> Sat, 16 May 2009 11:13:49 GMT</pubDate>
</item>
<item>
<title> ABX OnTime % For Week</title>
<description> 75.84% of antibiotics have been delivered ontime.</description
<pubDate> Sat, 1 May 2009 11:13:49 GMT</pubDate>
</item>
    </channel>
    </rss>
```

Figure 3.9 RSS Visualizer report generation.

Data Descriptions

Temporary Table Description

The tables discussed above contained large amounts of data that were not directly needed for the calculation and production of a requested report by the agent or end user. The software compiled the pertinent data in a temporary table with the following columns as illustrated in Table 3.6.

Each of these columns is either drawn from the input tables via a primary key relation, or populated via a stored procedure. The “rs_opsforabx” table contains all the necessary information to begin the calculations required by the various reports needed to populate the RSS feed, or text message delivery. Descriptions of the columns contained in the “rs_opsforabx” table are included.

In the code snippet in Figure 3.10, line 1 declares the method that will be refreshing the RSS Feed with the most recent data available. Lines 3 and 4 connect to the database and retrieve a listing of hospital statistics to include within the RSS feed. Line 6 begins a loop through all of the valid statistics. In lines 8 – 11, the agent is setting up a string builder object that will be used to compose the RSS item and then getting the exact SQL commands that must be run from the database. Lines 13-28 look at the administrator options for this RSS item to determine what look back period should be used (i.e. past 30 days, past 6 month, etc.). Lines 33 through 44 connect to the database and construct a standard SQL query to retrieve the information needed for this item during the correct look back period. Lines 45 through 49 actually retrieve the information from the database and store it in a dataset. Lines 51 through 56 retrieve and format the name for this rss item and then place a properly formatted value in the description field. Lines 58 through 62 actually create the XML for a valid RSS item within the string builder and ensures that they are formatted properly for web display. Upon exiting the loop, lines 67 through 69 write these items out to the webserver so that they may be served to RSS reader.

Table 3.7 Summary of "rs_opsforabx" Work Table (continues to next page)

Table Column Name	Description
Patient name	Last name of the patient
Patient number	Unique hospital assigned number that is patient specific
Visit number	Unique hospital assigned number that is visit specific. This is combined with the patient number to make a unique patient visit to the hospital
Operation number	Unique hospital assigned number that is surgery specific. When combined with the patient and visit number forms a unique patient visit and operation (it is possible for a patient during one hospital visit to have multiple surgeries.
Surgeon name	Last name of surgeon scheduled to perform the surgery
Anesthesia provider name	Last name of the anesthesia provider logged into the EARK system recording the antibiotic administration for the surgery.
Operation time	Scheduled time of the operation in the system
Patient in room time	Time the anesthesia provider recorded that the patient entered the operating room for the scheduled surgery.
Surgical incision time	Time the anesthesia provider recorded that the patient received a surgical incision for the operation
1-hour abx issued times	Time that the anesthesia provider recorded that an antibiotic was administered to the patient.
2-hour abx (vanco) issued times	Time the anesthesia provider recorded that the patient received a second antibiotic if one was ordered
Any noted reason that abx was given late or missed	Delineation for why an antibiotic was purposefully missed or given late
Any noted reason that the surgery was started late	Anesthesia provider documentation for why a scheduled surgery was started late.
Whether or not the operation at hand required ABX to be issued	Anesthesia provider documentation for whether a particular surgery does not require an antibiotic to be administered (and thus to be excluded from the on time calculation.)

```
Private void DoRSSRegenIfNeeded() {

CPADatabasedbContext = new CPADatabase(DBSettings.ConnectionString);
List<rs_RSSFeed>feeds =dbContext.rs_RSSFeeds.Where(rs.IsSelected=true).ToList();

    foreach (CPAPortal.Database.rs_RSSHospitalStat stat in feeds ) {

        StringBuilder rssItem = new StringBuilder();

        string directiveCommand = stat.Directive.Split(' ')[0].Trim();
        string directiveTimeFrame = stat.Directive.Split(' ')[1].Trim();

DateTime beginning = DateTime.Now;
DateTime ending = DateTime.Now;


        switch (directiveTimeFrame)  {
          case "Today":
            beginning = ending.Date;
            break;

          case "Week":
            beginning = ending.AddDays(-7);
            break;

          case "Month":
            beginning = ending.AddDays(-30);
            break;
     }

    string db Val = null;

    using (System.Data.SqlClient.SqlConnection con = newSystem.Data
 .SqlClient.SqlConnection (CPAPortal.Database.DBSettings.ConnectionString)) {
        con.Open();


         SqlCommand command com = new SqlCommand(directiveCommand, con);
         com.CommandType = CommandType.StoredProcedure;
         com.Parameters.AddWithValue("@BeginningDate", beginning);
         com.Paramaters.AddWithValue("@EndingDate", ending);
         com.CommandTimeout = 180;

com.paramters.AddWithValue("@Scope", "-1");
DataSet ds = new DataSet();
SqlDataAdapter sda = new SqlDataAdapter(com);

sda.Fill(ds);
dbVal = ds.Tables[1].Rows[0][0].ToString();
}
if (stat.Name.Contains("%")) {
dbVal = decimal.Parse(dbVal).ToString("P").Replace(" ", "");
}

string title = stat.Name;
string description = stat.SurroundingText.Replace("[X]", dbVal);

rssItem Append("<item>\r\n");
rssItem Append("<title>" + System.web.HttpUtility.HtmlEncode(title) + "</title>\r\n");
rssItem Append("<link>" http://webportal/cpawebportal/default.aspx?true?tme=" + DateTime.Now.Ticks.ToString() + "<link>\r\n");
rssItem Append("<description>" + System.web.HttpUtility.HtmlEncode(description) + "</description>\r\n");
rssItem Append("</item>\r\n");
   rssItems.Add(item);
}
```

Figure 3.10 Retrieval of data for specified date range and RSS feed refresh.

Stored Procedures

Stored procedures are used to call subroutines in the SQL database (relational database). In this research project the data base processing server used these stored procedures to gather information from the EARK database to be utilized for a particular report. In Figure 3.11, the stored procedure calls to the EARK database for information about results for on time antibiotic performance that can be arranged with respect to a particular end user (eg. anesthesia provider) within a certain date range.

Software Modeling

Software processes were divided into two categories: On demand and independent schedule. The on demand software processes are initiated by a

```
[rs_ABXOnTimePerformance]
  (@BeginningDate datetime, --the beginning date of the range
   @EndingDate datetime, --ending date of the range@Scope varchar(40),
        –just a specific anesthesia provider
   @bysurgeon varchar(40) = -1  --just a specific surgeon
```

Figure 3.11 Stored procedure retrieving on time antibiotic performance for specific anesthesia provider or department.

clinical end user or an admin. The software responds by either calling an ASP.net page, processing login data to determine what report information is permissible to be displayed to that viewing end user (ie the administrator user views all members data on all screens, while clinical end users only see their data identified in the SMS TEXT message along with aggregate anonymized data.

The independent schedule processes are put in place by the admin user to generate reports of requested data and then delivered via a schedule that follows the request of the administrator user. An example of this process was the delivery of individualized antibiotic on time percentage data compared to the group aggregate on time percentages for a given time period.

Hardware Requirements

The following discussion focuses on the minimum hardware requirements needed for this research. Hardware necessary for the clinicians to input data into the EARK, servers needed to process and display the data for the RSS feed and deliver the SMS text messages to participant's cellular phones is discussed.

Client Hardware

The hardware required for the client portion of this research consisted of a computer workstation configured with no less than the minimum hardware requirements given by the vendor of the electronic anesthesia record keeper, and for running Microsoft Windows XP SP3. In this study the workstations used by the clinicians were Intel Core 2 Duo 2 Ghz machines, with 1 gigabyte (GB) of random access memory (RAM), and an 80 (GB) hard drive (HD). These workstations were mounted on the side of the anesthesia machines and connected to a 19" touchscreen monitor that facilitated the data entry during the conduct of the anesthetic for the surgery.

The RSS visualizer workstation utilized in this study was an Apple MacPro 2Ghz Intel Core 2 Duo with 2 GB RAM and a 160 GB HD. To optimally display the RSS feed containing the averaged daily, weekly and monthly on-time percentage statements, Apple's Tiger Operating system was configured to display the RSS visualizer screensaver on a 30 inch cinema display after two minutes of inactivity. This workstation was centrally located in a high traffic gathering area for the anesthesia department.

Lastly, study participants needed to own and operate a cellular telephone capable of receiving SMS TEXT messages. The type of cellular phone was not important as the system was compatible with a large variety of models.

Server Hardware

Server hardware was housed inside the hospital datacenter. Four were required for research conducted. The first was a data processing server (DPS). It was an HP quad core 2 Ghz Xeon processor with 8 GB RAM and 120 GB HD. The DPS ran Windows Server 2003 as an operating system and was connected to the hospital network. via gigabit ethernet. The server was configured to be allowed access to the webserver to store RSS feeds. It was also configured to allow access to a Simple Mail Transfer Protocol (SMTP)

The second server was configured as a webserver. It was an HP quad core 2 Ghz Xeon processor with 8 GB RAM and 120 GB HD. The webserver ran Windows Server 2003 as an operating system and was connected to the hospital network via gigabit ethernet. The webserver had Microsoft Internet Information Services 6.0 (IIS) installed. Microsoft .NET 3.5 services were also installed and running.

Software Requirements

Webserver Software Requirements

The software on the webserver used required the availability of Microsoft Internet Information Services (IIS). The hosted html and asp pages were accessible only from within the hospital intranet. ASP pages on the server required .NET 3.5 services to be running. The web server also required access to the EARK database via the backend.

Data Processing Software Requirements

The data processing software required access to the EARK database. .NET 3.5 services were required to be running. The software required access to the webserver to store updates RSS feeds. In addition there was a requirement for the data processing software to have access to an SMTP relay server with access to the internet to allow for the ability of the system to send SMS TEXT messages to the participants.

Clinician Software requirements

Anesthesia providers participating in this study had to utilize an electronic anesthesia record keeping system. This software provides for electronic recording of the clinician administering and documenting the preoperative antibiotic administration time, and the time of surgical incision.

Security

For the purposes of this research study, security of information was addressed in several ways. Physical security to the workstations was provided through keycard and badge access to areas containing patient sensitive health information. The workstation that accessed the RSS (which was in a high traffic break room area) feed was not capable of running reports that would reveal an individual participant’s information. Only aggregate data was viewable at the RSS Visualizer screen site.

Text messages were only delivered to participant’s cellular phones via a process where the participant had entered in the information for his cellular number and provider at an earlier date when the system had been installed prior to the gathering of any data for the study.

As was previously described, the data used for our research were stored on the facility’s database server. This database server was located on the facility’s intranet and was secured to the standards of the facility’s security department. The procedures and work table that were created to facilitate this research was added on the same database server and was deemed secure by the facility’s security department.

Two different outputs were generated by this research: the RSS feed, and the text messages. Both outputs contained only aggregate data (eg. “The department timely antibiotic delivery rate was 59% on time for the past week”). No individual cases were listed in either of the outputs for this research, so no patient or operation information was present. There was no sensitive information in any of the outputs. The RSS feed was hosted on a web server on the facility’s secure intranet and not exposed to the internet or outside world. The only computers that could connect to the RSS feed were present on the facility’s intranet and required a hospital login to access. The text messages are sent offsite through a mail relay server which also was inspected by the facility’s internal security team.

CHAPTER FOUR: RESULTS

This chapter provides an overview of the characteristics of the sample and a description of the results by phase of the study. It begins with a sample description and then proceeds to a description of the three different phases of the research.

Sample

A total of 29 anesthesia providers participated providing anesthesia to 8475 surgical cases during the study period. This represented 100% of the anesthesia providers at the institution. The participants were all board-certified anesthesiologists and were predominately male (89.7%) with a mean age of 43.8 years. Table 4.1 provides the demographic characteristics of the sample.

Table 4.1 Demographic Characteristics of the Sample of Anesthesia Providers

Characteristic	ange	ean	Standard Deviation
Age (years)	0	3.8	7.88
Experience in anesthesia (years)	3	1.42	7.83
Experience with EARK (years)	9	.88	3.51

On Time Delivery of Preoperative Antibiotics

Phase one consisted of the cases performed during the first 20 weeks of the calendar year. Phase two began at week 21 when the RSS electronic feedback intervention began. The third phase began in week 37 at which time the SMS text message notification feedback was instituted. Table 4.2 presents a summary of the results by phase.

Table 4.2 Summary of On Time Delivery of Antibiotics by Intervention Phase

	Phase 1 Control	Phase 2 Screensaver (Intervention 1)	Phase 3 SMS text messages (Intervention 1 + 2)
Weeks in phase	20	16	6
Total # of eligible surgical cases in phase	4346	3011	1118
# of on time antibiotics	2900	2387	942
% of documented on time antibiotics	66.7	79.2	84.2

Weekly means of on time percentages are illustrated in Figure 4.1. The average percentages for timely antibiotic administration for all providers for each week of the study were calculated from the raw data extract and plotted on the graph. There is a general positive slope indicating the percentages increased throughout the study.

Average on time percentage of on time antibiotic administration was determined for each phase of the study. The percentages are graphed in Figure 4.2 as estimated marginal means to illustrate the amount of change in mean on time percentages from one phase to another. The chi-square test for independence analysis indicated a significant difference in the data points ($\chi^2 = 220.319$; $p = <.001$, $n=8476$).

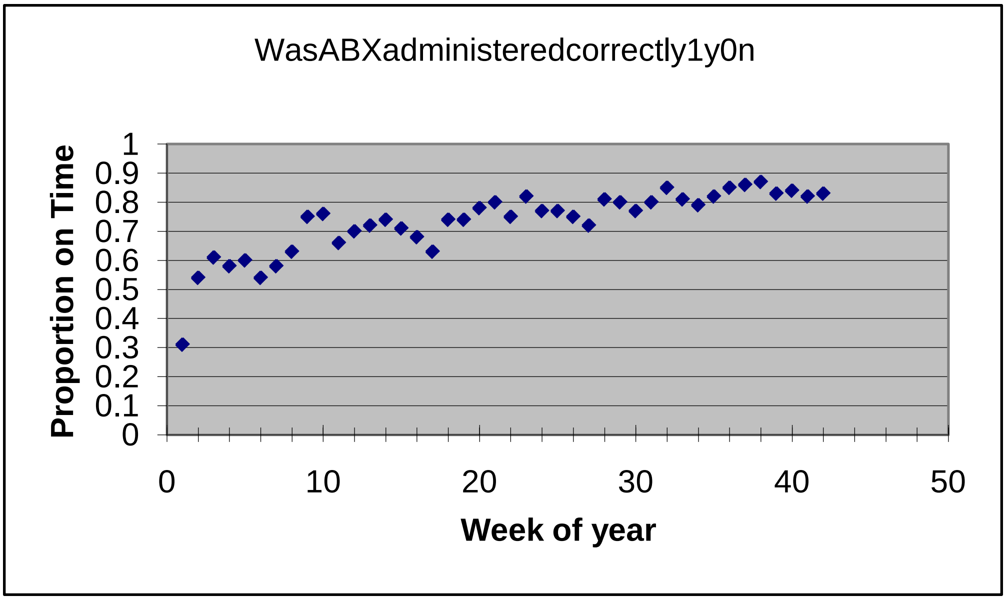

Figure 4.1 Average departmental timely administration percentage for each week.

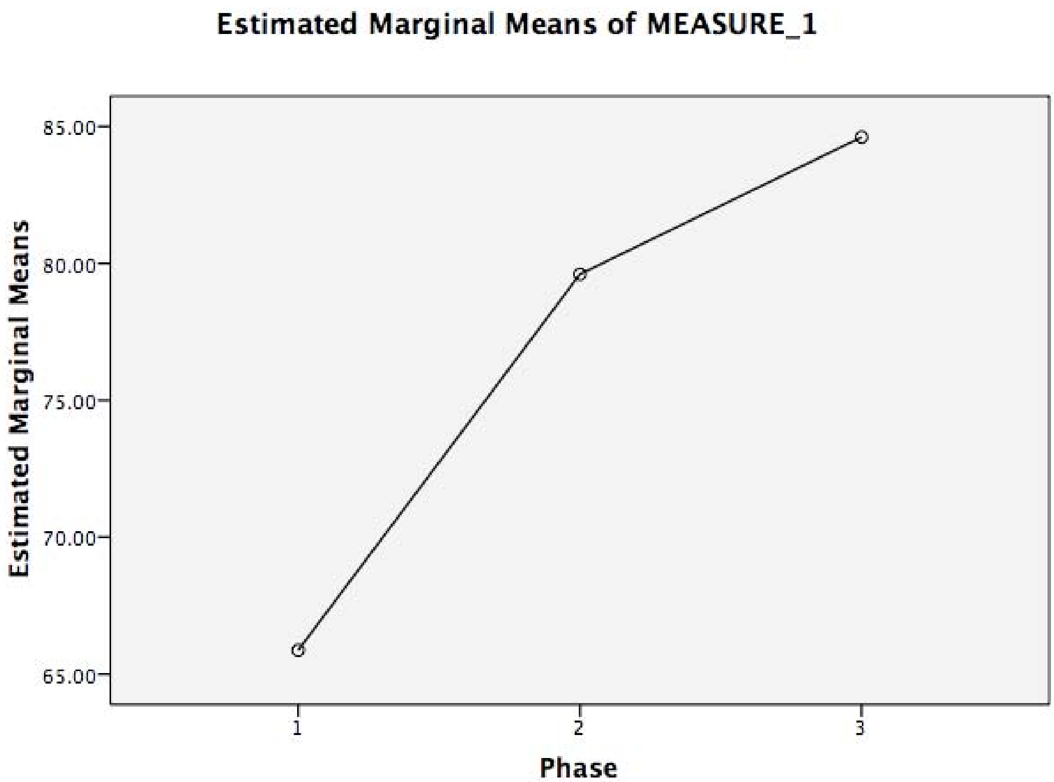

Figure 4.2 Magnitude of change by percentage between phases 1, 2, and 3.

Figure 4.3 shows the percentage of two week group of providers that documented on time preoperative antibiotic administration percentage of greater than or equal to 75%, 85% and equal to 100%. The x-axis is now grouped into two week groupings (TWCW#). Each column represents all providers participating (administering antibiotics in surgical cases that qualified for analysis) in a two week period. On the x-axis the week with the notation of intervention 1 is the week the screensaver intervention was implemented. The column with intervention 2 is the week SMS text messages were initiated.

McNemar's test for change was used to examine the departments performance of timely documentation greater than or equal to 85% in each two week group during the last six weeks of each phase of the study (see Table 4.3). This was to approximate ideal performance of documentation of timely antibiotic administration prior to the intervention. A significant change was detected from phase 1 to phase 3 ($p < 0.01$)

Table 4.3 Differences Between Each Phase During the Last Six Weeks of Each Phase During the Study

Phase examined	McNemar exact sig. (2 sided)	Pearson Chi-Square	Sig (2-sided)
Phase 1 to 2	.065	2.397	.122
Phase 2 to 3	.375	8.31	.004
Phase 1 to 3	.006	1.93	.164

Figure 4.3 shows a graph of the improvement groups throughout the interventions. Each line shows an achievment level for documentation of a timely antibiotic at >75%, >85%, and 100% of the time. Almost 58% of the providers

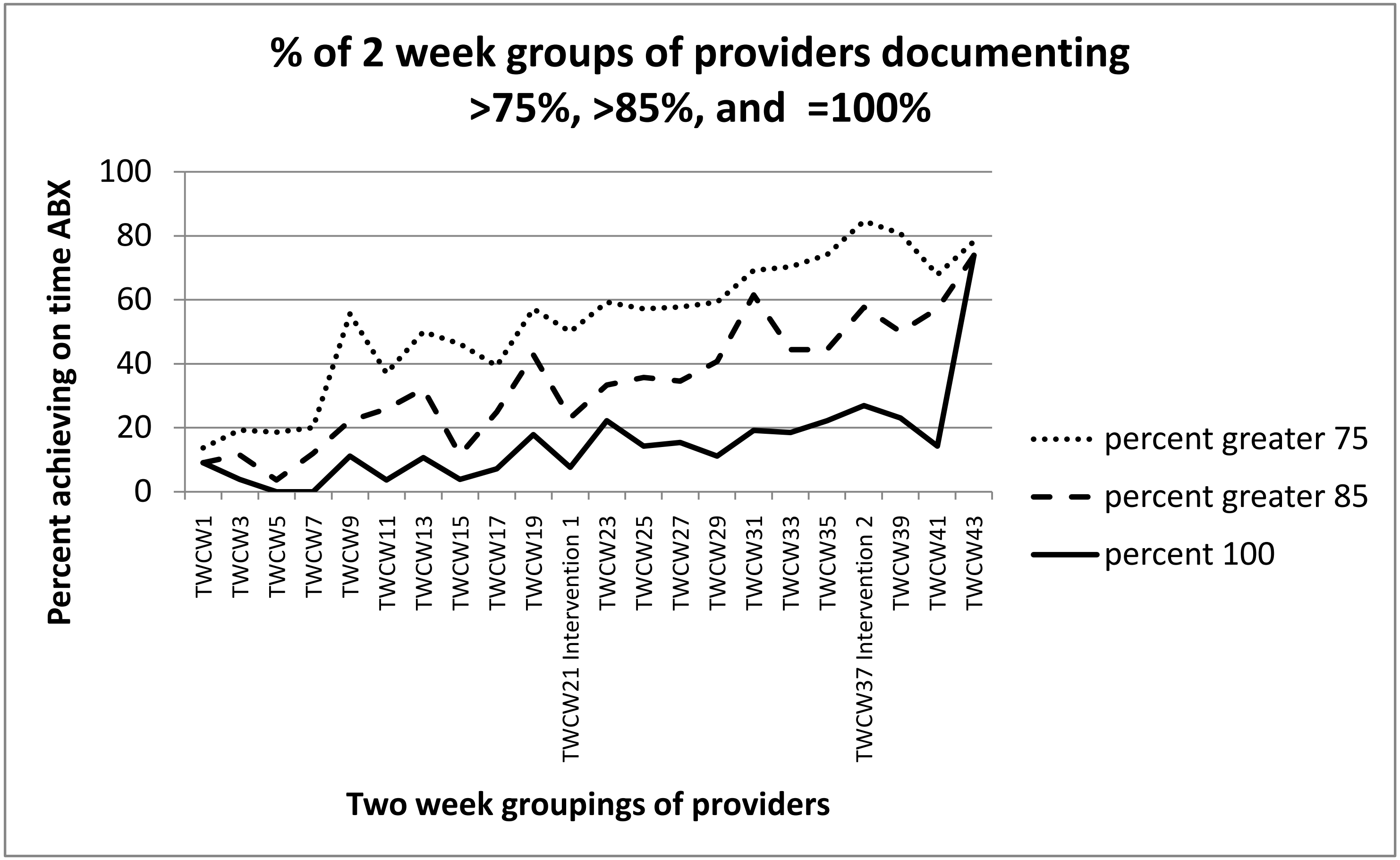

Figure 4.3. On time percentage improvement groupings.

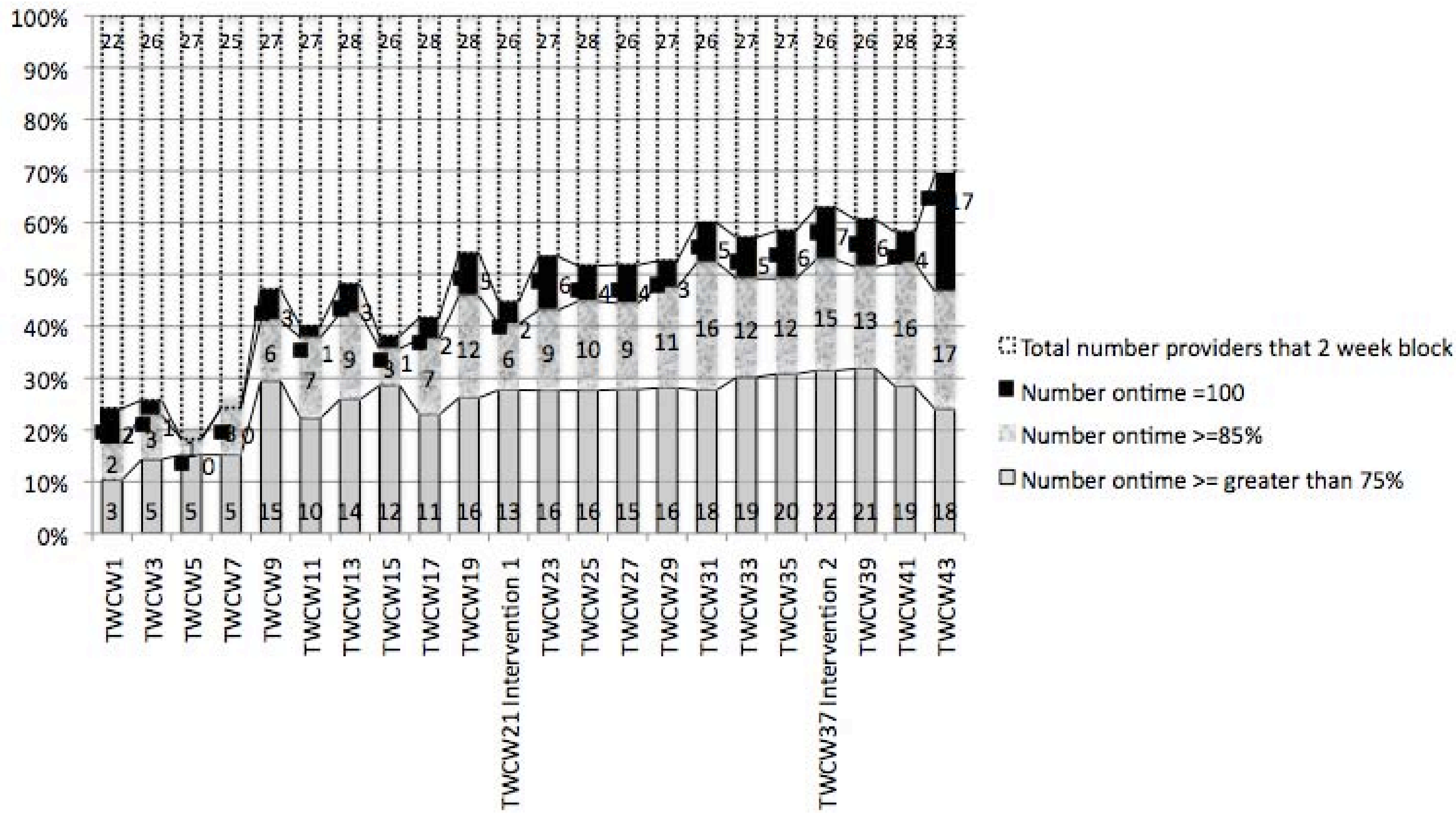

Figure 4.4. Total number of providers in each two week group that documented on time preoperative antibiotic administration at >75%, >85%, and = 100% of the time.

documented >75% at the beginning of phase 2, and increased to 84% by the beginning of phase 3.

Figure 4.4 shows a stacked bar graph of the same data but shows the total number of providers participating in each two week group calculation. The stacks are represented as percentages of the group visually, but show the numbers out of the total in the group for the different achievment levels of >75%, >85%, and 100% compliance for the documentation of timely antibiotic administration. The start of phase 2 shows only two providers achieving 100% compliance with documentation, and the number of providers achieving that level increases to seven as of the last calculation of the study.

CHAPTER FIVE: DISCUSSION

The data show an increase in compliance levels with documentation of antibiotic administration guidelines associated with feedback containing aggregate and individualized performance. The feedback was delivered via an RSS screensaver on a large display in a high traffic area, and via SMS text messages sent to study participants' cellular phones. The mean percentage of documented timely administration during the first phase of the experiment was 66.7%. This mean increased to 79.2% in phase 2, and further improved to 84.2% in phase 3.

Phase Differences

Post hoc multiple comparison tests between phase 1 and 2, 2 and 3, and 1 and 3, revealed that each intervention had its own distinct effect. Maulchy's test for sphericity was calculated to be > 0.5 which shows a homogenous sample group for each of the phase comparisons. Tests of within-subjects differences shows a significant linear trend and an overall incremental change from phase to phase. Although there was a significant linear trend ($F = 100.35$, $p = .001$) and an overall incremental change ($F = 10.73$, $p = .003$) between each phase, the difference in the F values indicates that a larger change occurred between phases 1 and 2 than between phases 2 and 3. A significant difference in calculated mean percentages for the documentation of timely administration of preoperative antibiotics was detected.

Level of Improvement

After analyzing the degree of improvement in the aggregate group, the question of whether there was any change in the number or percentage of providers who achieved an excellent level of documentation of timely antibiotic administration prior to surgery was explored. Using the data set, the number of percentages greater than 75%, greater than 85%, and = 100% was calculated and charted over time. The data show that indeed the number and percentage of providers who improved to an excellent level increased significantly over the control phase.

It is interesting to note that the percentage of providers achieving perfect documentation of timely antibiotic administration appears to increase sharply (by nearly a factor of 4) during the last two weeks of the investigation. One reason this may have occurred is the increased awareness of the measure and discussion among study providers (at this point each provider participating in the study had received at least 3 SMS text message reminders of their performance). This could have contributed to the sharp increase.

Strengths and Limitations

The strengths of this study are the large database, the established use of an EARK by the participants, and the methodology by which the data were collected. The limiting factors of the study include small number of providers who were delivered the intervention, the duration of time allocated for analysis of the interventions, and the controversial nature of the data (which can be argued, is one of its strengths as well).

The dataset used for calculation of the on time percentages was sufficiently large to detect changes from one phase to the next. Perhaps the most interesting strength came from the method of data calculation from the EARK. The hospital is required to report timely antibiotic administration for a number a databases and national quality measure clearing houses. The reported percentage for every month during the course of the study was always greater than 90%.

The method used by the hospital was to take a random sample of anesthesia records from one week of the month, with approximately 1.5% of the cases performed each month included in the sampling. Once these were selected a reviewer would peruse through the anesthesia record and other documentation to investigate whether the documentation of the antibiotic was present and or if any exclusions were present that would prevent the record from being included in the month's calculations.

In contrast, the software system used to extract the data for this study was able to survey all qualifying cases as determined by the anesthesia providers performing the documentation. At the start of the study there was a large disparity between the reported on time percentage of the sampled method used by the hospital, and the electronic method that analyzed every qualifying case. Compliance with documentation levels improved throughout the intervention phases to more closely approximate the last reported measure (which was 95% at the time of this writing).

The EARK at the study hospital had been in place for just over 2.5 years. Since the demographic data report 4.88 years of experience with EARKs, it is likely that participants had experience either during their clinical training or at a previous employment utilizing an EARK. Data were not gathered on the length of employment at this particular facility.

For the purposes of analysis, the software used to extract the data returned all cases in the database that had documentation of a surgical incision event. This list was then filtered by the extraction software automatically to exclude cases for which antibiotics are not routinely given such as endoscopy/ colonoscopy procedures, and intraocular lens implant procedures. The EARK uses a specific documentation event that is available to the anesthesia provider to indicate that a preoperative antibiotic was: (a) not required, (b) not indicated, or (c) purposefully held because of the nature of the surgical procedure. One example of the latter is when a patient needed to have a culture taken from an existing infection. In this case the surgeon needs to obtain a specimen from the wound prior to antibiotics being administered and this would naturally happen after the patient is anesthetized and the documentation of the beginning of the surgical procedure. In these types of instances the notation was made in the anesthesia record and allowed the exclusion of the case from the software's calculation of antibiotic timely administration. This same item also contained an option to document the timely administration of an antibiotic within one hour prior to incision, but its presence alone did not exclude the case from analysis. It was felt that documentation was complete when the existence of the antibiotic administration time dosage and route was present in the anesthesia record, that the presence of both items (an antibiotic administered in a timely manner, as well as the presence of a confirmatory statement by the anesthesia provider) provided a robust method of determining proper administration and documentation.

It was the department policy that the anesthesia provider would be responsible for the task of administering the preoperative antibiotic. This included if it was given in the holding area of the perioperative area. If the anesthesia provider confirmed that an antibiotic was given, it required the notation in the record of exactly what time it was administered. This process yielded a dataset of surgical procedures of over 8000 cases during the different phases of the analysis.

When examining the individual provider data, efforts were made to identify usual practice behaviors for participation in anesthetics throughout the year. One method that was investigated was to group each anesthesia provider's case participation into two week blocks. If an anesthesia provider participated in less than four cases in a two week period, the on time percentage was withheld from the calculation of weighted averages for on time percentage by provider for each two week period. This was pursued to attempt to establish homogeneity of the study population and to make an attempt to be more representative of a provider's overall usual practice patterns in relation to preoperative antibiotic administration. Although the mean on time administration percentages appear to diminish for a short period after the intervention began, the overall slope of the graph is in the positive direction. The data could also be skewed because of the grouping of two weeks for the purposes of analysis.

Providers who participated in less than five surgical procedures for a two week period were excluded from the analysis of aggregate on time percentage calculation for that two week period. If a provider performed only one case there was potential to score either 100 or 0%, which would exaggerate the change in practice for timely preoperative antibiotic estimation week to week. A Microsoft Excel formula was employed that examined the range of cases that a provider was involved in for a two week period group. Once these were eliminated, weighted averages were used to give weight to on time percentages where the providers were involved in a greater proportion of cases for that two week grouping, and less to those who were not as prevalent in their participation in cases for that week. After the electronic feedback phase of the research was implemented, data points were analyzed to detect any effect on the timeliness of preoperative antibiotic administration by the same participants over a similar time period. The interventions were independently effective in improving the documentation of on time preoperative antibiotics.

Implications for Future Research

Future research will need to further investigate the effectiveness of different types of reminders and feedback alternatives. This research utilized a screensaver RSS feed type application and the delivery of SMS text messages. Other modalities of information delivery exist and should be examined. Email messaging is frequently discussed as one method of feedback. Comparing the effectiveness of email feedback to SMS text messaging would be beneficial to help determine the best practice for delivering this type of summary information.

There are also several other quality measures that should be focused on in the coming era of quality care delivery. Feedback on the level of compliance with delivering patients to the Recovery unit normothermic, as well as compliance with maintaining intraoperative levels of euglycemia will undoubtedly be important focus areas in the coming years (Carr, et al., 2005; Doenst et al., 2005, Kurz, Sessler, & Lenhardt, 1996).

Implications for Clinical Practice

Many technologies exist in the perioperative environment that have potential to contribute to improved quality care. This research study demonstrates the use of feedback that is tailored to the individual recipient has the capacity to influence the level of compliance with documentation of the timely administration of preoperative antibiotics. In the future this technology could be expanded to deliver other quality measures that are important for the delivery of quality of care. While it is certainly possible to deliver multiple data points using SMS text messages and screensaver applications, campaigns promoting better quality measure performance for shorter duration of times (rotations) will likely be employed.

Ideally, this type of flexibility for data mining and delivery would be integrated into the application for the anesthesia record itself, allowing the delivery of information to be more proximate to the point of care delivery. Currently this ability requires the development of customized software and database customization. Time will tell as the technology and applications of it develop instep.

Summary

It is well documented that the delivery of preoperative antibiotics in a timely manner reduces surgical morbidity and mortality. It is also well documented that health care providers do not always follow closely the guidelines supported by strong evidence in the literature. The use of electronic reminders has been shown to effectively change the practice behaviors of health care providers by as much as 4.2% (Shojania et al., 2009).

Tailored communication modalities change behavior because recipients respond favorably to the notion that informational material was made specifically for them. Personalization gives the perception of enhanced relevance to the recipient. Most research has focused on behavioral response variables to tailored communication. Future research will investigate the effect of individual learning style, as well as the style of information presentation on effectiveness of behavior change (Kreuter & Holt, 2001).

Successful interventions to effectively change clinical practice are sufficiently persuasive and relevant to the population for which the intervention is intended for. This can be done by tailoring messages to the individual intended recipient (Gagnon et al., 2009).

It is an exciting time to be in healthcare's electronic age. As more and more systems move to the electronic methodology, the opportunity for the intelligent use of the information generated by clinicians can be used to generate feedback data useful in providing dynamic, meaningful, tailored information that have the potential to improve the care provided to patients, and improve their outcomes for survival in the healthcare system.

APPENDIX

Data Tables

Table 1 Full Listing and Description of the "iopdata" Table

Table Column Name	Description
patient_sys:	Recordkeeper's patient ID
visit_sys:	Recordkeeper's visit ID
subvisit_sys	Not Used
op_sys	Recordkeeper's operation ID
object_sys	Not Used
template_sys	Not Used
enteredby_sys	Staff Member who entered the event
date_observation	Time the event took place
date_entered	Time the event was entered
date_deleted	If the event was later deleted, time it was removed
deletedby_sys	If the event was later deleted, person who deleted
current_value	Is the event currently valid
value	Text string describing the event
annotation_exists	Not used
denies	Not used
iopdata_sys	Table identity

Table 2 Full Listing of the "or_schedule" Table

Table Column Name	Description
patient_sys	Recordkeeper's patient ID
visit_num	Hospital's patient ID
visit_sys	Record keeper's visit ID
patient_cur_stat	Not used
patient_location	Not used
hospital	Not used
admit_date	Not used
disch_date	Not used
disch_type	Not used
carrier	Not used
service	Not used
injury_date	Not used
admit_att_sys	Not used
carrier2	Not used
er_att_sys	Not used
current_visit	Not used
disch_service	Not used
pcp_sys	Not used
room	Not used
unit	Not used
data_source	Not used
billing_service	Not used
department	Not used

Table 3 Full Listing and Descriptions of the "visit" Table (continues for 4 pages)

Table Column Name	Description
ssi op id	hospital's operation number
Date	date of operation
actual room	room operation is to take place within
proc short	short version of the procedure
patient name	name of the patient
reg num	hospital's patient number
visit num	hospital's visit number
dob	Patient date of birth
age today	Calculated age in days or years as is appropriate
gender	gender assignment
ssn	Social Security number
or rec num	Not used
patient type	Not used
anesthes1 idx	Not used
anesthes1 name	Not used
anesthes1 sys	Not used
anesthes2 idx	Not used
anesthes2 name	Not used
anesthes2 sys	Not used
anesthes3 idx	Not used
anesthes3 name	Not used
anesthes3 sys	Not used
anesthetist1 idx	Not used
anesthetist1 name	Not used
anesthetist1 sys	Not used
anesthetist2 idx	Not used
anesthetist2 name	Not used
anesthetist2 sys	Not used
perf idx	Not used
perf name	Not used
perf sys	Not used

asa status	Not used
emergent	Not used
anesthesia type	Not used
perf case type	Not used
surgeon idx	Not used
surgeon name	Not used
surgeon sys	Not used
resident idx	Not used
resident name	Not used
resident sys	Not used
assist1 idx	Not used
assist1 name	Not used
assist1 sys	Not used
assist2 idx	Not used
assist2 name	Not used
assist2 sys	Not used
assist3 idx	Not used
assist3 name	Not used
assist3 sys	Not used
proc med	Not used
sched time	Not used
case minutes	Not used
admitting in	Not used
fwrm in	Not used
asu preop In	Not used
holding rm in	Not used
circulator present	Not used
patient present	Not used
anes Res Present	Not used
anes fac pres induct	Not used
surg res present	Not used
induction start	Not used
induction stop	Not used

surg faculty in	Not used
incision	Not used
surg faculty out	Not used
dressing end	Not used
anes fac pres awaken	Not used
patient out	Not used
asu postop in	Not used
asu postop out	Not used
pacu in	Not used
pacu out	Not used
disch ready	Not used
est out	Not used
dynaview start	Not used
last event	Not used
case type	Not used
unit	Not used
bed	Not used
comment	Not used
consent signed	Not used
Consent comment	Not used
ordering doc	Not used
patient comment	Not used
latex sensitive	Not used
procedure long	Not used
preop dx	Not used
postop dx	Not used
dept id code	Not used
case service	Not used
proc service	Not used
surg service	Not used
delay preop	Not used
delay preop desc	Not used
delay preop time	Not used

delay Intraop	Not used
delay Intraop desc	Not used
delay Intraop time	Not used
delay postop	Not used
delay postop desc	Not used
delay postop time	Not used
delay misc type	Not used
delay misc code	Not used
delay misc desc	Not used
delay misc time	Not used
accepted by	Not used
phone home	Not used
phone work	Not used
display order	Not used
created	Not used
updated	Not used
status	Not used
family id	Not used
aka	Not used
update flags	Not used
institution sys	Not used

Table 4 Full Listing of the "staff" Table (continues for 2 pages)

Table Column Name	Description
staff_sys	Record keeper's staff identifier
name_last	Clinician staff member's last name
name_first	Clinician staff member's first name
staff_type	Documentation staff type (anesthesiologist, certified registered nurse anesthetist, registered nurse, etc.)
staff_idx_num	Not used
staff_oth_num	Not used
active	Not used
hospital	Not used
uid	Hospital's staff Identification. It was used to track who was logged in when a documentation entry was made.
service	Not used
initial	Not used
sign_template	Not used
discipline	Staff worker type (surgery, anesthesia, quality assurance)
billing_service	Not used
password_change_required	Not used
credentials_suffix	Not used
name_kana_first	Not used
name_kana_last	Not used
name_kanji_first	Not used
name_kanji_last	Not used
default_screen_action_sys	Not used

Table Column Name	Description
password	Not used
release_notes_ack	Not used
name_middle	Not used

Table 5 Full Listing of the "mardoses" Table (continues for 2 pages)

Table Column Name	Description
profile sys	Identified the dose within the system then related back to the IOP
profiledetail sys	Not used
dose sys	Identity of the drug (antibiotic)
scheduled time	Not used
dose time start	Not used
dose time end	Not used
dose status	Not used
med id	Not used
med_sys	Anesthesia record keeper drug identifier definition. This was used to relate to a separate column of user defined drugs.
quantity	Not used
dose min	Not used
dose max	Not used
dose administered	Not used
dose units	Not used
volume	Not used
volume units	Not used
route	Not used
admin method	Not used
admin site	Not used
dispense amount	Not used
dispense units	Not used
administered by	Not used
witnessed by	Not used
waste text	Not used
patient response	Not used
comment	Not used
reason sys	Not used

unit	Not used
userstamp	Used to relate to staff table identical column
timestamp	Used to relate to staff table identical column
current value	Not used
data source	Not used
iv flow rate	Not used
iv flow rate units	Not used
iv flow type	Not used
bag number	Not used
blood type	Not used
deleted by	Not used
date deleted	Not used
notgiven reason sys	Not used
addmdn	Not used
addflow	Not used
fluid rate	Not used
fluid rate units	Not used
flagged	Not used
patient scanned	Not used
dose scanned	Not used
pain score sys	Not used
dose substatus	Not used

Table 6 Full Listing of the "orderpharmacy" Table

Table Column Name	Description
drug sys	Electronic anesthesia record keeper's drug identifier
institution sys	Not used
facility sys	Not used
ndc	Not used
pharm id	Not used
pharm id alt	Not used
generic name	Not used
brand name	Not used
dea class	Identifies the type of medication (antibiotic)
dose form	Not used
strength	Not used
strength unit	Not used
volume	Not used
volume unit	Not used
therapeutic class	Not used
mfg	Not used
cost	Not used
charge	Not used
active	Not used
num ordered	Not used
decimals	Not used
dateinserted	Not used
dateupdated	Not used
override	Not used
fdb ndc	Not used
dose type	Not used
display	Not used
list first	Not used
overrideRxVerify	Not used
non formulary	Not used

Table 7 Example and Description of the "rs_opsforABX" Table (continues for 2 pages)

Table Column Name	Description
Patient name	Last name of the patient
Patient number	Unique hospital assigned number that is patient specific
Visit number	Unique hospital assigned number that is visit specific.This combined with the patient number is combined to make a unique patient visit to the hospital
Operation number	Unique hospital assigned number that is surgery specific. When combined with the patient and visit number forms a unique patient visit and operation (it is possible for a patient during one hospital visit to have multiple surgeries.
Surgeon name	Last name of the surgeon who was scheduled to perform the surgery
Anesthesia provider name	Last name of the anesthesia provider who was logged into the electronic anesthesia record keeping system for the purposes of recording the antibiotic administration for the surgery.
Operation time	Scheduled time of the operation in the system
Patient in room time	Time the anesthesia provider recorded that the patient entered the operating room for the scheduled surgery.
Surgical incision time	Time the anesthesia provider recorded that the patient received a surgical incision for the operation
1-hour abx issued times	Time that the anesthesia provider recorded that an antibiotic was administered to the patient.
2-hour abx (vanco) issued times	Time the anesthesia provider recorded that the pattient received a second antibiotic if one was ordered
Any noted reason that abx was given late or missed	Delineation for why an antibiotic was purposefully missed or given late
Any noted reason that the surgery was started late	Anesthesia provider documentation for why a scheduled surgery was started late.
Whether or not the operation at hand required ABX to be issued	Anesthesia provider documentation for whether a particular surgery does not require an antibiotic to be administered (and thus to be excluded from the on time calculation.)

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VITA

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